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*Title:* Low-Energy Photon Spectroscopy Data in Support of ASTM Method Development

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**Low-Energy Photon Spectroscopy Data in Support of ASTM  
Method Development**  
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**Abstract**

The Isotope and Nuclear Chemistry (C-INC) Radioassay Facility at Los Alamos National Laboratory (LANL) has been in operation since 1948 to measure fission-product and actinide activities from the U.S. weapons testing program. Since the cessation of testing in 1992, the facility has remained in continuous operation by analyzing samples for environmental, bioassay and research projects. In addition to the many gamma spectroscopy systems, two independent planar germanium detectors are employed for measurement of x-rays and low-energy gamma rays. These counters were used to collect data of select isotopes to support the development of a new ASTM standard, "Standard Practice for High-Resolution Low-Energy Photon Spectrometry of Water". This standard is being developed by ASTM Subcommittee D19.04 as a tool for measurement of low-energy gamma-rays and x-rays from approximately 4 keV to 150 keV. This work describes empirical counting results obtained from traceable sources covering the energy range of interest. Specifically, the isotopes used were  $^{59}\text{Ni}$ ,  $^{55}\text{Fe}$ ,  $^{241}\text{Am}$ ,  $^{129}\text{I}$ ,  $^{109}\text{Cd}$ , and  $^{57}\text{Co}$  which provide a range of 5.9 to 136 keV. Mixed nuclide sources were also counted for the purpose of providing data for coincidence summing effects. All data is presented in hardcopy and accompanying electronic form.

**I. INTRODUCTION**

The C-INC radioassay facility maintains the capability to measure alpha, beta, gamma and neutron radiation through the use of more than 100 detector systems. The facility was originally designed to assist the weapons testing program, but it has evolved into a multi-user facility, supporting the LANL bioassay and environmental restoration projects, and other programs critical to the Laboratory's national security mission. The capability of detecting x-rays and low-energy gamma rays has been little used in the past, although it has been maintained throughout the decades. All detectors are calibrated using standards traceable to NIST or the former NBS, and the team participates in several cross-check and interlaboratory studies to maintain certification by the various programs that the facility supports.

The data collected here is being provided to ASTM Subcommittee D19.04 as a reference for precision data in the development and implementation of a new ASTM standard, "Standard Practice for High-Resolution Low-Energy Photon Spectrometry of Water". The standard is being developed to assist and facilitate the quantification of difficult-to-measure isotopes such as  $^{55}\text{Fe}$ ,  $^{59}\text{Ni}$ ,  $^{129}\text{I}$  and  $^{241}\text{Am}$ . Low-energy spectroscopy is recommended for such nuclide measurements at government and nuclear power facilities.

The counters used in this study (counters 13 and 18) are intrinsic germanium planar detectors with Be windows. These counters are designed to accommodate counting of small aqueous samples. The C-INC radioassay facility uses 5 ml in a standard 20 ml polyethylene scintillation vial as a calibrated geometry (Type 2). The vial has the following dimensions:

Height – 61 mm from base to top of closure  
Outer Diameter – 26 mm  
Closure thickness – 1.6 mm

At 5 ml, the surface of the volume is approximately 51 mm from the top of the closure when sealed.

The radioassay facility operates on GMT using the julian calendar day and fraction thereof, to the nearest thousandth, followed by the year in parentheses. This date/time format will be used throughout.

The radioassay facility also owns a Si(Li) detector which is being modified to hold a Type 2 vial under vacuum in the detector housing for ultra-low energy measurements. Future work will focus on the development of this counting system.

## 11. SOURCE PREPARATION

NIST traceable standards were obtained, where feasible, for use in this study. Aliquots of the standards were taken to prepare pure isotopic sources, as well as a source containing a mixture of several of the isotopes.

The <sup>109</sup>Cd standard was prepared from solution R0/355/18 provided by AEA. 0.0244g of the original solution (13.42 µCi/g) was diluted to 5 ml with 0.5 M HCl in a standard Type 2 vial. The resultant standard contained 0.324 µCi at 336.5000(00).

The <sup>59</sup>Ni standard was prepared from solution 62205-16 provided by Analytics. 0.6151 g of the original solution (0.686 µCi/g) was diluted to 5 ml with 3.0 M HNO<sub>3</sub> in a standard Type 2 vial. The resultant standard contained 0.422 µCi at 215.7083(01).

The <sup>57</sup>Co standard was prepared from solution 62206-16 provided by Analytics. 2.9593 g of the original solution (0.508 µCi/g) was diluted to 5 ml with 0.5 M HCl in a standard Type 2 vial. The resultant standard contained 1.505 µCi at 226.7083(01).

The <sup>55</sup>Fe standard was prepared from solution 62275-16 provided by Analytics. 2.6230 g of the original solution (0.194 µCi/g) was diluted to 5 ml with 0.5 M HCl in a standard Type 2 vial. The resultant standard contained 0.510 µCi at 229.7083(01).

The  $^{129}\text{I}$  standard was prepared from solution 62320A-16 provided by Analytics. 4.3683 g of the original solution (0.105  $\mu\text{Ci/g}$ ) was diluted to 5 ml with DI water in a standard Type 2 vial. The resultant standard contained 0.457  $\mu\text{Ci}$  at 250.7083(01).

A mixed standard containing all of the above isotopes was prepared from the traceable solutions noted. The preparation details are included in Table 1. The final activities are decay corrected to 9/7/01 (250.7083(01)). The final volume of the mixed source slightly exceeds the desired geometry of 5 ml, but the effect on geometry is expected to be insignificant.

Isotope	Original Activity ( $\mu\text{Ci/g}$ )	Mass Added (g)	Final Activity ( $\mu\text{Ci}$ )
$^{109}\text{Cd}$	<b>13.42</b>	<b>0.0242</b>	<b>0.214</b>
$^{57}\text{Co}$	<b>0.508</b>	<b>2.0333</b>	<b>0.973</b>
$^{59}\text{Ni}$	<b>0.686</b>	<b>0.3785</b>	<b>0.260</b>
$^{55}\text{Fe}$	<b>0.194</b>	<b>2.4028</b>	<b>0.461</b>
$^{129}\text{I}$	0.105	<b>0.5011</b>	<b>0.053</b>

**Table 1 – Preparation data for the mixed source.**

The  $^{241}\text{Am}$  standard was obtained from stock solution from the C-INC alpha operations. A 5 ml fraction was placed in the appropriate vial geometry and "certified" by gamma spectroscopy in the radioassay facility. The counters used for quantification of the standard are currently calibrated using NIST traceable sources. The results of four certification counts on two separate counters (**42** and **76**) in different positions are contained in Table 2.

Counter-Shelf	DPM	$\mu\text{Ci}$
42-12	2.023E+6	0.911
<b>76-3</b>	<b>2.112E+6</b>	0.951
<b>76-7</b>	<b>2.172E+6</b>	<b>0.978</b>
<b>76-12</b>	<b>2.003E+6</b>	<b>0.902</b>
	<b>Average</b>	<b>0.936</b>
	<b>SD</b>	<b>0.031</b>
	<b>RSD</b>	<b>3.3%</b>

**Table 2 – Certification of the  $^{241}\text{Am}$  source.**

### III. COUNTING

Counter 13 is a Princeton Gamma-Tech intrinsic germanium planar detector with 400  $\text{mm}^2$  active area and 10 mm thickness. It has a **6 mil**(0.15 mm) Be window and a fixed pulsed optical feedback preamplifier. The detector face to window distance is 5 mm. The

detector operates at -1500V with rated resolution of 268 eV at 5.9 keV and 535 eV at 122 keV. This detector has been in operation at LANL since 1977 in various configurations. For this study, it is supplied by an ORTEC 659 HVPS and a Tennelec TC205A linear amplifier provides signal processing. A Canberra Series 35Plus MCA is used for operator interface and to transfer counting data to the various analytical routines used by C-INC. A plexiglass sample holder is fixed to the detector can which allows reproducible positioning of samples on ten different heights from the detector. The Type 2 vial geometry can be placed no closer than shelf 9, which is the position used for this study. In this configuration, the base of the vial is 65 mm from the detector window and the top of the source volume is approximately 54 mm from the window.

Counter 18 is an ORTEC LOAX intrinsic germanium detector with 2060 mm<sup>2</sup> active area and 19.5 mm thickness. A 0.5 mm Be window sits 3 mm from the crystal face. The detector operates at -3000V with factory-measured resolution of 374 eV at 5.9 keV and 595 eV at 122 keV. It is equipped with an ORTEC 659 HVPS, Canberra 2025 amplifier and series 35Plus MCA. This counter has an integrated 24-station, computer-controlled sample changing system which allows a sample to be positioned at one of 12 available heights from the detector. The steel sample holder is fabricated to accommodate various geometries including the Type 2 Vial. Shelf5 positions the top of the vial 20 mm from the detector window and 70 mm from the window to the top of the source volume.

Both detectors are configured as “downlookers” so that the source volume in the vial is away from the detector face. While this maximizes the amount of air and polyethylene between the source and detector, it would be expected to minimize **summing** effects, even when the vial is positioned nearest to the detector.

The standards were counted for lengths which would yield at least 10,000 peak area counts in the prominent peaks of interest. Seven measurements of each standard were obtained.

Several spectroscopy analysis codes are used in the counting facility to quantify sample counts, although only RAYGUN data is used in this study. RAYGUN, a precursor to the development of GAMMANL, is a rather simple spectral analysis tool that has been in use at LANL for decades. RAYGUN initially searches a spectrum and determines background regions. It then searches non-background regions and determines peaks, resolves multiplets, and provides peak area information. While it also performs isotope identification by user-defined libraries, that feature was not used for this study, as libraries had not been established to search for these low-energy peaks. The facility also utilizes many of the various commercially available analysis packages such as GAMMANL, UniSAMPO, etc. Raw spectral information is retained and archived should the ASTM committee request it for further or independent processing.

## IV. DATA ANALYSIS

### IV. A. Cadmium-109

The significant photon emissions from the decay of  $^{109}\text{Cd}$  by Browne & Firestone<sup>1</sup> are listed in Table 3.

keV	% photon yield	Type
<b>21.99</b>	<b>28.9</b>	$K_{\alpha 2}$
<b>22.16</b>	<b>54.5</b>	$K_{\alpha 1}$
<b>24.93</b>	<b>13.7</b>	$K_{\beta 1}$
<b>25.60</b>	<b>2.72</b>	$K_{\beta 2}$
<b>88.03</b>	<b>3.6</b>	E3

Table 3 –  $^{109}\text{Cd}$  photon emissions.

This list excludes the L-shell x-rays below 4 keV which are below the discrimination level for the counters. Additionally, photons at this energy and below would be highly attenuated by the vial closure and aqueous source volume.

Seven counts of the  $^{109}\text{Cd}$  source were obtained on counter 13. A summary of the results can be found in Appendix A. Figure 1 below is a portion of one of the spectra from 0 to approximately 100 keV. This view shows the 88 keV gamma ray with a FWHM of **0.55** keV. Figure 2 is an expanded view of this spectrum from 0 to approximately 35 keV. The Ge escape peaks from the 22 keV emission can be seen at **11.1 and 12.2 keV** (approximately **9.9** keV and 11 keV below the major peak). Likewise, the escape peaks from the **24.9** emission are detected at **14.0 and 15.0 keV**.

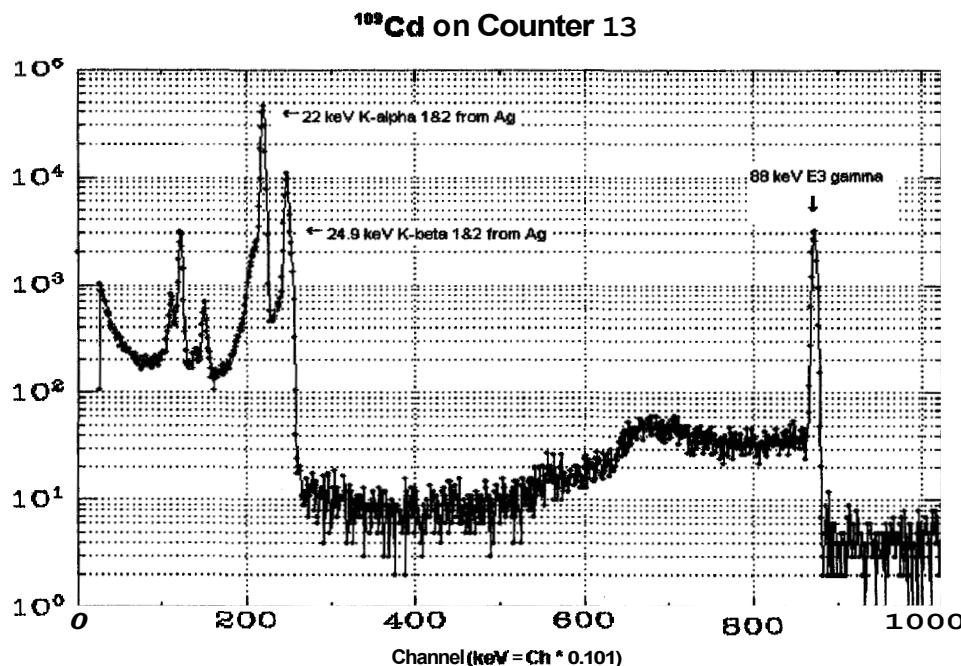


Figure 1 – Full spectrum of  $^{109}\text{Cd}$

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<sup>1</sup> E. Browne and R. B. Firestone, Table of Radioactive Isotopes, John Wiley & Sons, 1986

Figure 2 also shows in detail the shape of the **24.9** keV peak. Note the “hump” on the high energy side of the peak from the **2.7%** emission at **25.6** keV which cannot be resolved from the much more abundant **13.7%** emission at **24.9** keV. Also, the low energy side of the **22** keV peak displays a shoulder due to Compton scattering. At these energies, Compton scattering can present a difficult quantification problem as the scattered photon energy ( $E'$ ) is:

$$E' = E[1 + (E/m_e c^2)(1 - \cos \theta)]$$

where  $E$  is the original photon energy,  $m_e c^2$  is the electron rest mass, and  $\theta$  is the scattering angle. This gives a distribution of scattered photons with energies ranging from  $E$  down to  $E/(1+2E/(m_e c^2))$ . The low-energy shoulder of the **22** keV peak ranges from **20.3** keV to the full energy at **22.1** keV. The lower limit for scattering of the **24.9** keV emission is **22.6** keV, which poses no **significant** problem for the resolution of these peaks and the quantification of the activity. However, care must be exercised when identifying peaks **and** determining peak areas in this energy region. A review of Appendix A for the **22** keV peak areas indicate that RAYGUN produces consistent results for this peak.

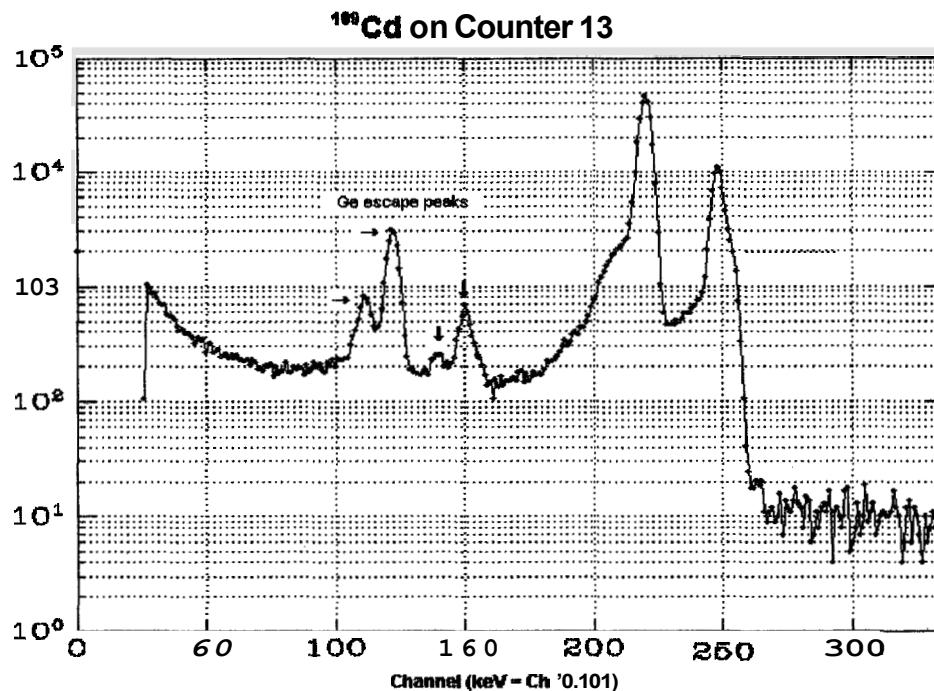


Figure 2 - showing the Ge escape peaks and the K- $\alpha$  and K- $\beta$  peaks.

By comparison, Figure 3 is a portion of the spectrum from the same  $^{109}\text{Cd}$  source on counter **18**. Note the presence of the **6.4** keV K- $\alpha$  x-rays from Fe. The steel sample holder in counter **18** is the source of the fluorescence x-rays from Fe. A hint of the K- $\beta$  x-rays from Fe at **7.1** keV may also be seen. Likewise, the **8.0** and **8.9** keV K- $\alpha$  and K- $\beta$  x-rays

**of Cu** are prominent due to the detector cryostat which **is** more exposed to the source in the counter **18** cave than in counter **13**.

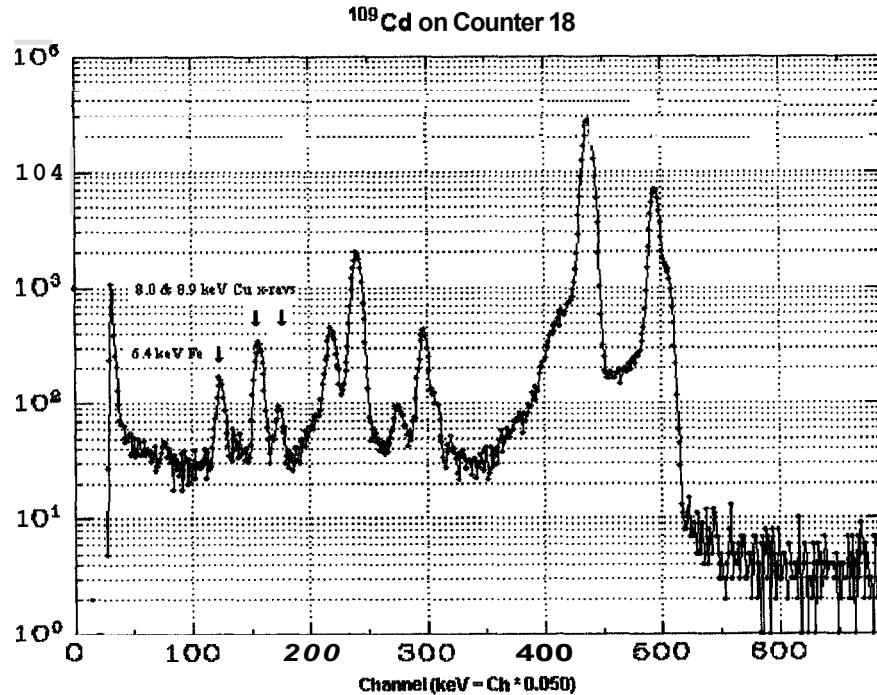


Figure 3 - showing the characteristic x-rays from Fe and Cu.

#### IV. B Cobalt-57

The significant photon emissions from the decay of  $^{57}\text{Co}$  by Browne and Firestone<sup>1</sup> are listed in Table 4:

keV	% photon yield	Type
6.39	16.4	$K_{\alpha 2}$
6.40	32.5	$K_{\alpha 1}$
7.06	5.8	$K_{\beta 1}$
14.41	9.54	M1
122.06	85.5	M1+E2
136.47	10.7	E2

Table 4 –  $^{57}\text{Co}$  photon emissions.

Seven counts of the  $^{57}\text{Co}$  standard were obtained on counter **13** and the results are summarized in Appendix B. Figure 4 below shows a full-scale spectrum **of one of those** counts and Figure 5 shows **an** expanded view from 0 keV to approximately 20 keV. Figure 6 shows an expanded view of a counter **18** spectrum.

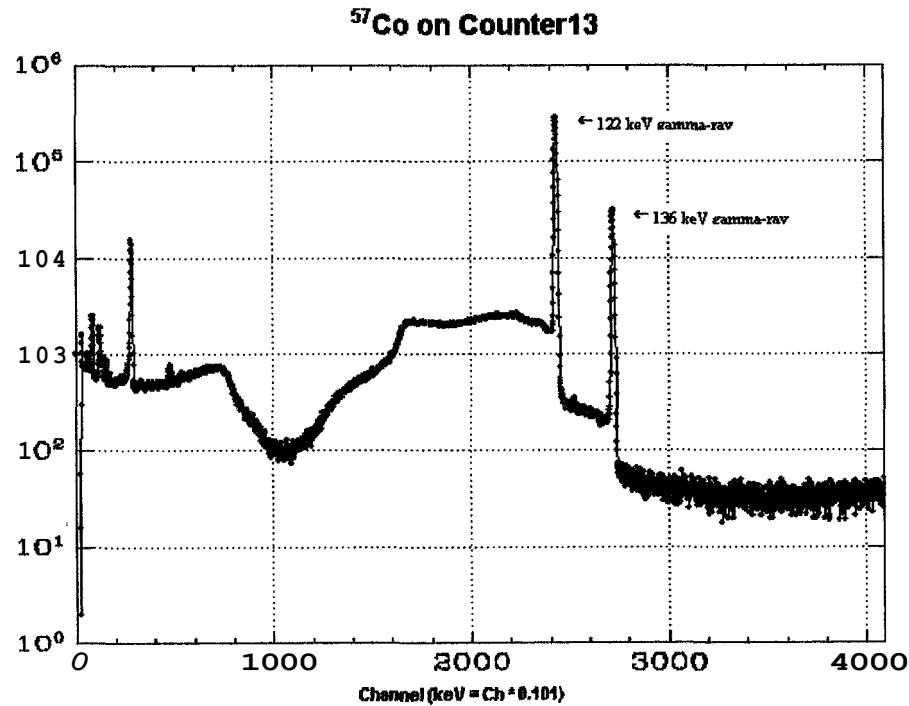


Figure 4 – Full energy  $^{57}\text{Co}$  spectrum.

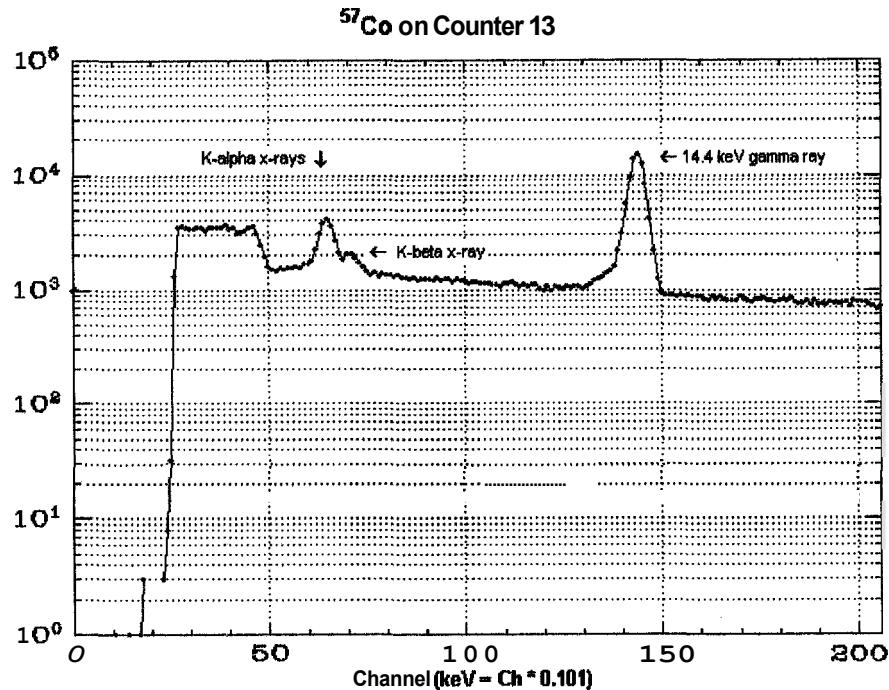


Figure 5 – K x-rays and M1 gamma of  $^{57}\text{Co}$ .

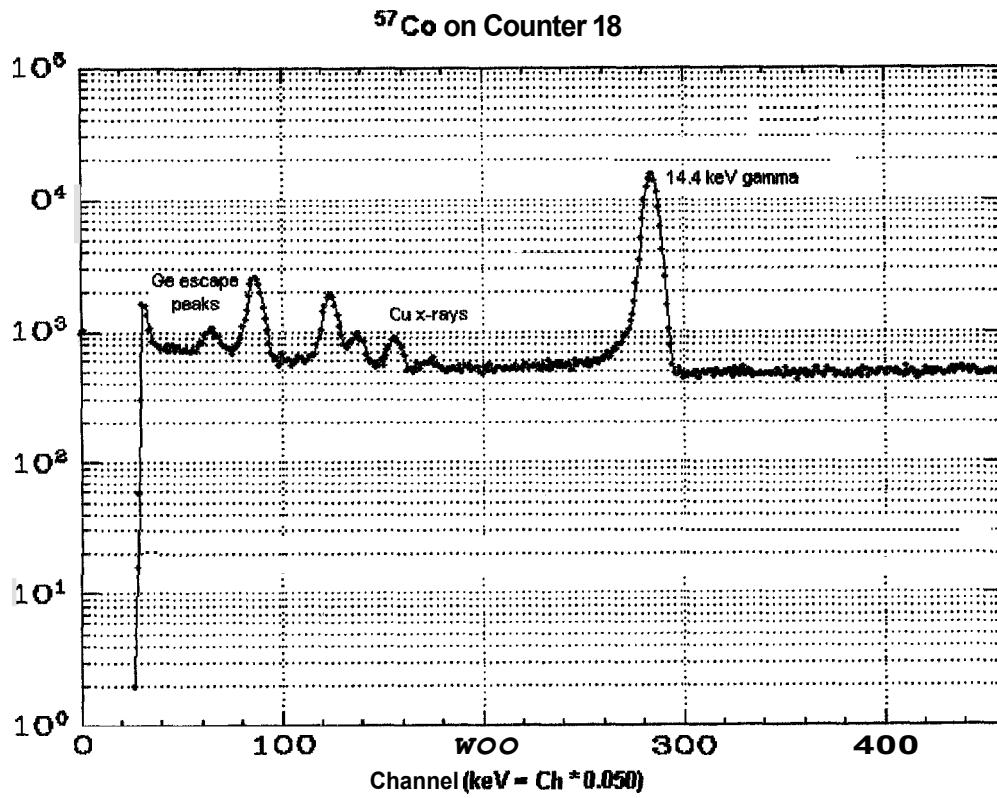


Figure 6 – Low energy spectrum of  $^{57}\text{Co}$ .

#### IV. C. Nickel-59

The significant photon emissions from the decay of  $^{59}\text{Ni}$  by Browne and Firestone<sup>1</sup> are listed in Table 5.

keV	% photon yield	Type
6.92	9.9	$K_{\alpha 2}$
6.93	19.6	$K_{\alpha 1}$
7.65	3.56	$K_{\beta 1}$

Table 5 –  $^{59}\text{Ni}$  photon emissions.

Seven counts of the  $^{59}\text{Ni}$  standard were obtained on each counter and the results are contained in Appendix C. Figure 7 below shows a counter 13 spectrum from 0 keV to approximately 16 keV and Figure 8 is the same standard as counted on 18. The resolution of these peaks is similar on the two counters and RAYGUN does a sufficient job of determining the peak areas. Also note the sum peak at approximately 13 keV in the much larger counter 18 detector.

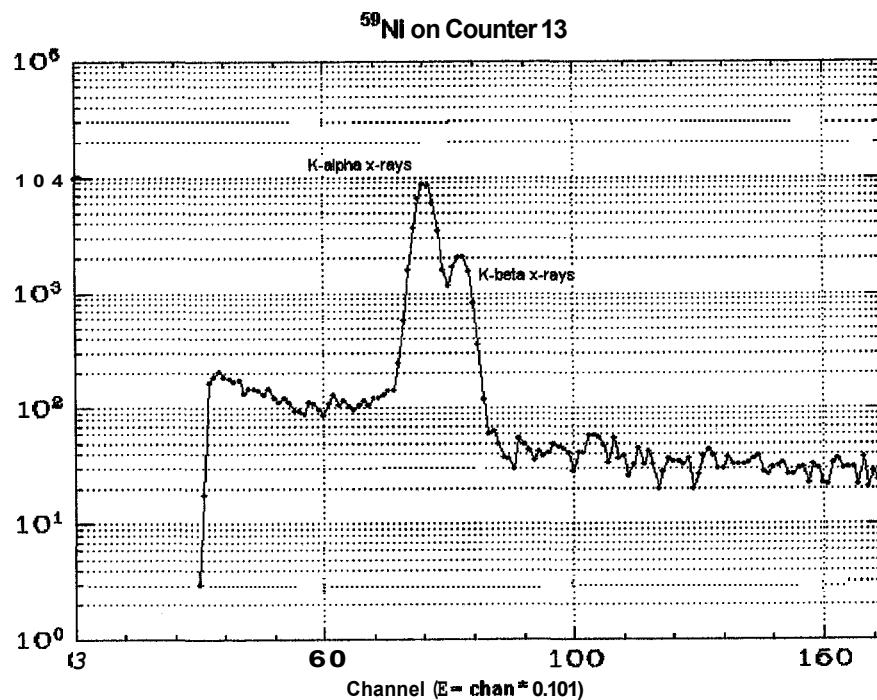


Figure 7 – K x-rays of <sup>59</sup>Ni

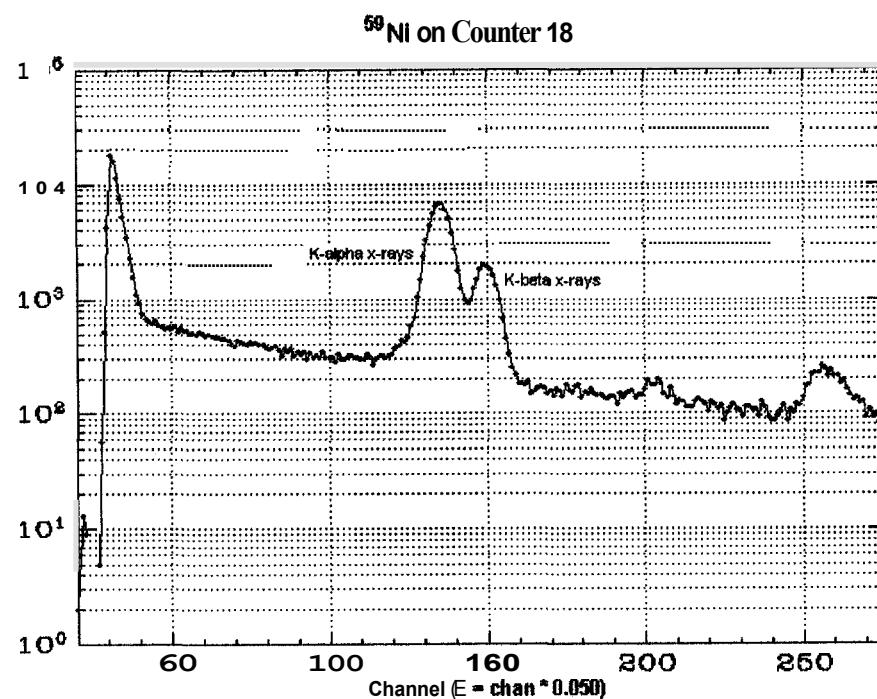


Figure 8 – K x-rays of <sup>59</sup>Ni

#### IV. D. Iron-55

The significant photon emissions from the decay of  $^{55}\text{Fe}$  by Browne and Firestone<sup>1</sup> are listed in Table 6.

keV	% photon yield	Type
5.89	8.2	$\text{K}_{\alpha 2}$
<b>5.90</b>	<b>16.2</b>	$\text{K}_{\alpha 1}$
6.49	2.86	$\text{K}_{\beta 1}$

Seven counts of the  $^{55}\text{Fe}$  standard were obtained on each of the two counters and the raw counting data are contained in Appendix D. The spectra from the two counters are displayed in Figures 9 and 10. Note in comparison to Figure 7 that the resolution of counter 13 degrades near 6 keV. The data in Appendix D shows that RAYGUN quantifies the multiplet as a single peak in counter 13.

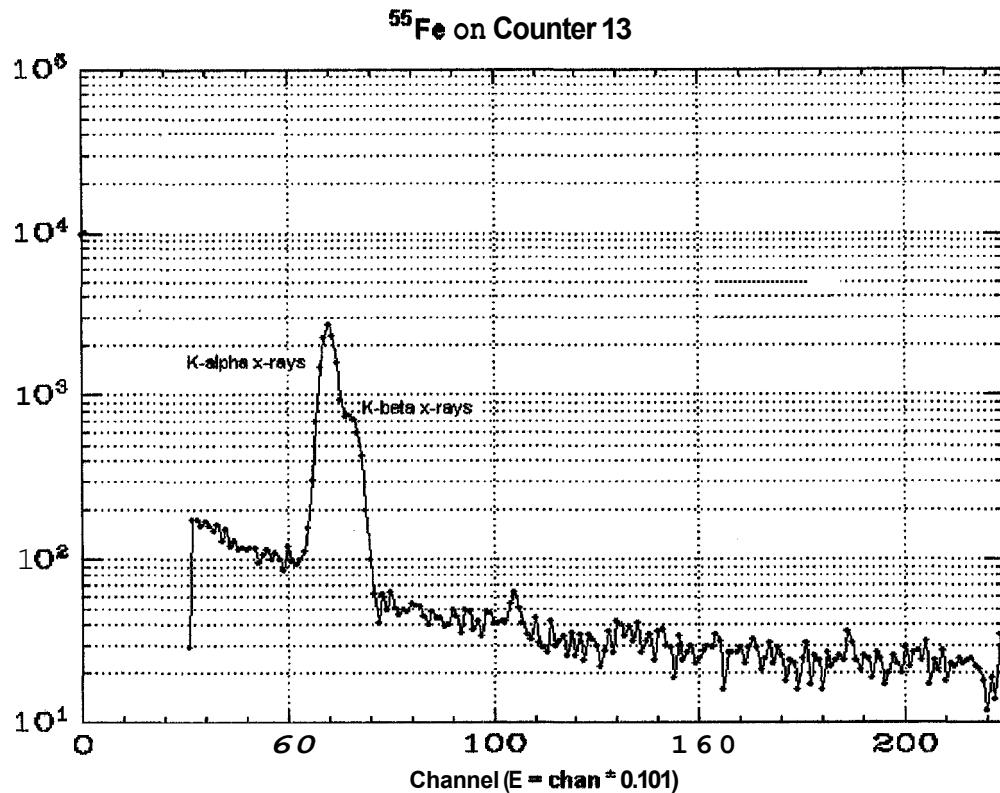


Figure 9 – X-rays of  $^{55}\text{Fe}$

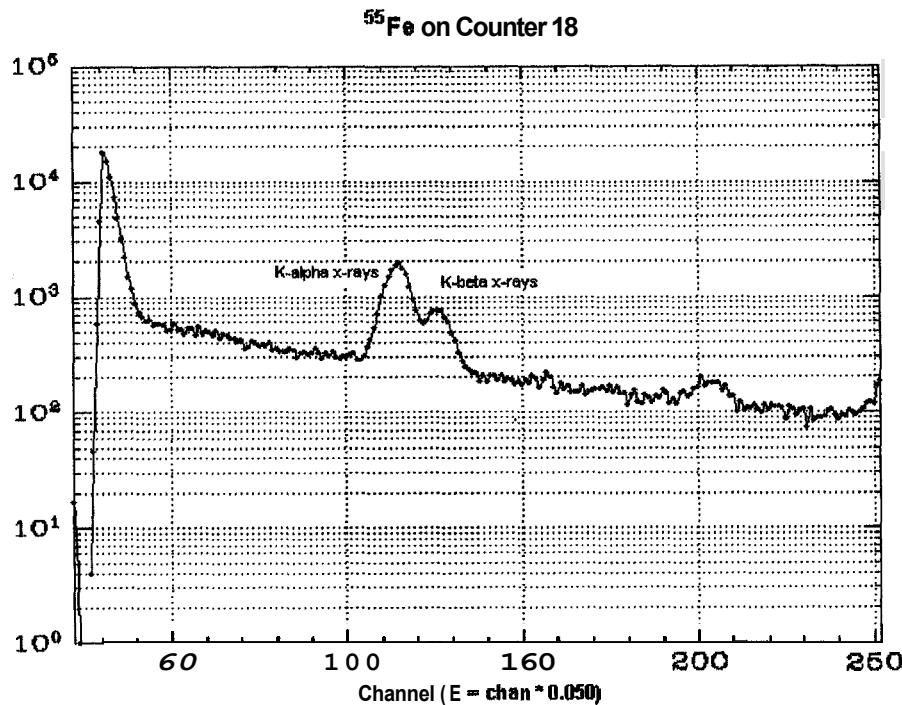


Figure 10 – X-rays of  $^{55}\text{Fe}$

#### IV. E. Iodine-129

The significant photon emissions from the decay of  $^{129}\text{I}$  by Browne and Firestone<sup>1</sup> are listed in Table 7.

keV	% photon yield	Type
3.63	0.12	$L_\ell$
3.96	0.06	$L_\eta$
4.10	3.4	$L_\alpha$
4.52	3.0	$L_\beta$
5.12	0.4	$L_\gamma$
29.46	20.4	$K_{\alpha 2}$
29.78	37.8	$K_{\alpha 1}$
33.61	10.2	$K_{\beta 1}$
34.61	2.4	$K_{\beta 2}$
39.57	7.5	M1+E2

Table 7 –  $^{129}\text{I}$  photon emissions.

Seven counts of the  $^{129}\text{I}$  standard were obtained on each of the counters and the raw counting data is included in Appendix E. Figure 11 shows a portion of the counter 13 spectrum from 0 to 45 keV and Figure 12 shows the same spectrum on counter 18.

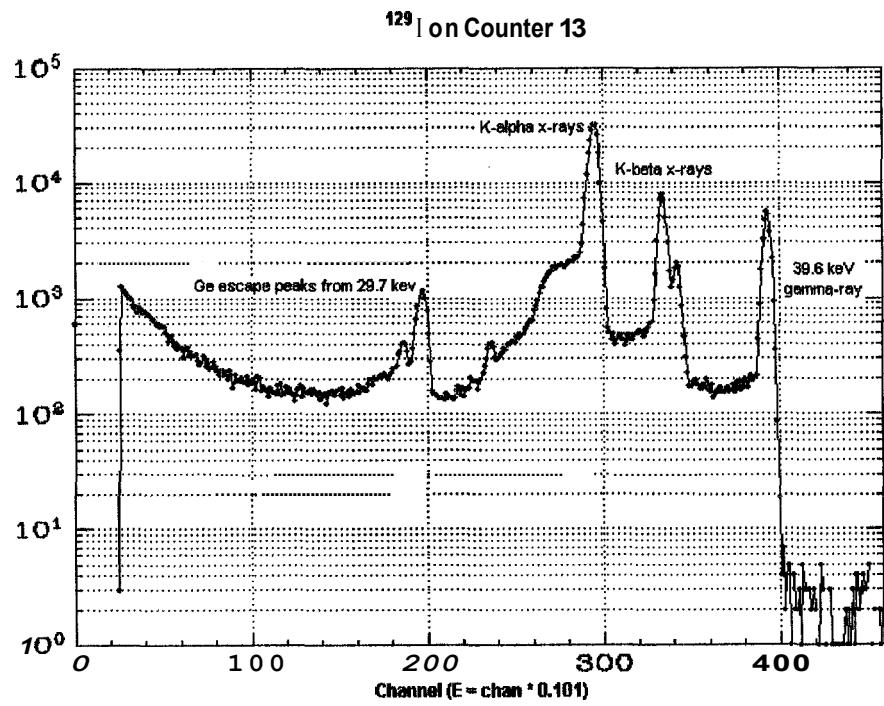


Figure 11 – Gamma ray and x-rays of  $^{129}\text{I}$

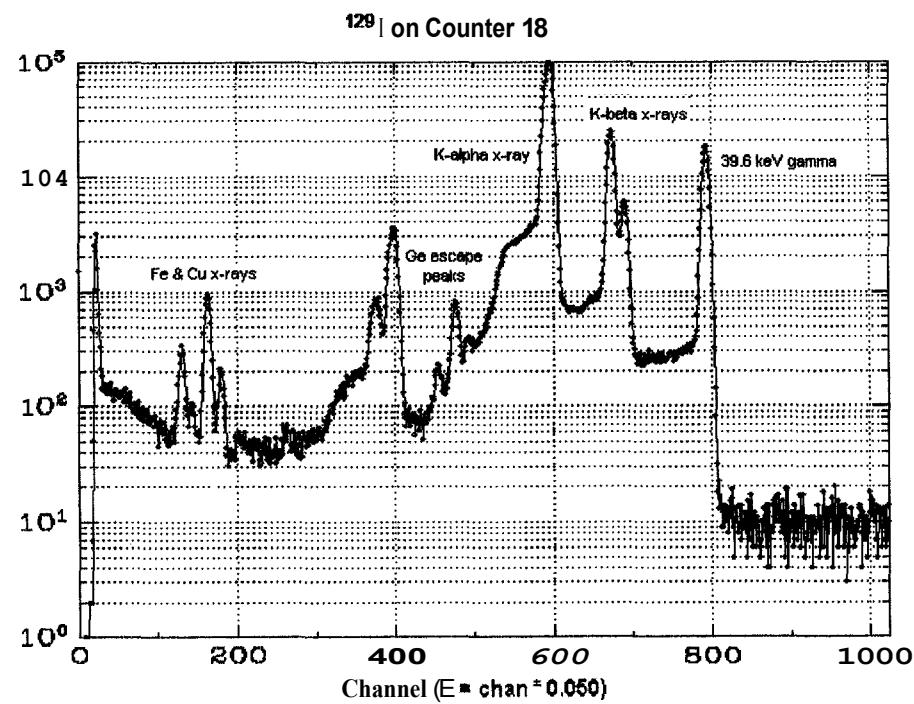


Figure 11 – Gamma ray and x-rays of  $^{129}\text{I}$

#### IV. F. Americium-241

The significant photon emissions from the decay of  $^{241}\text{Am}$  by Browne and Firestone<sup>1</sup> are listed in Table 8.

keV	% photon yield	Type
11.87	0.81	$L_\ell$
13.93	13.0	$L_\alpha$
17.61	20.2	$L_\beta$
21.00	5.2	$L_\gamma$
26.34	2.4	E1
33.19	0.12	M1+E2

Seven counts of the  $^{241}\text{Am}$  standard were obtained on each of the counters and the raw counting data is included in Appendix F. Figure 12 shows a portion of the counter 13 spectrum from 0 keV to approximately 80 keV, and Figure 13 is a similar spectrum of the same standard on counter 18.

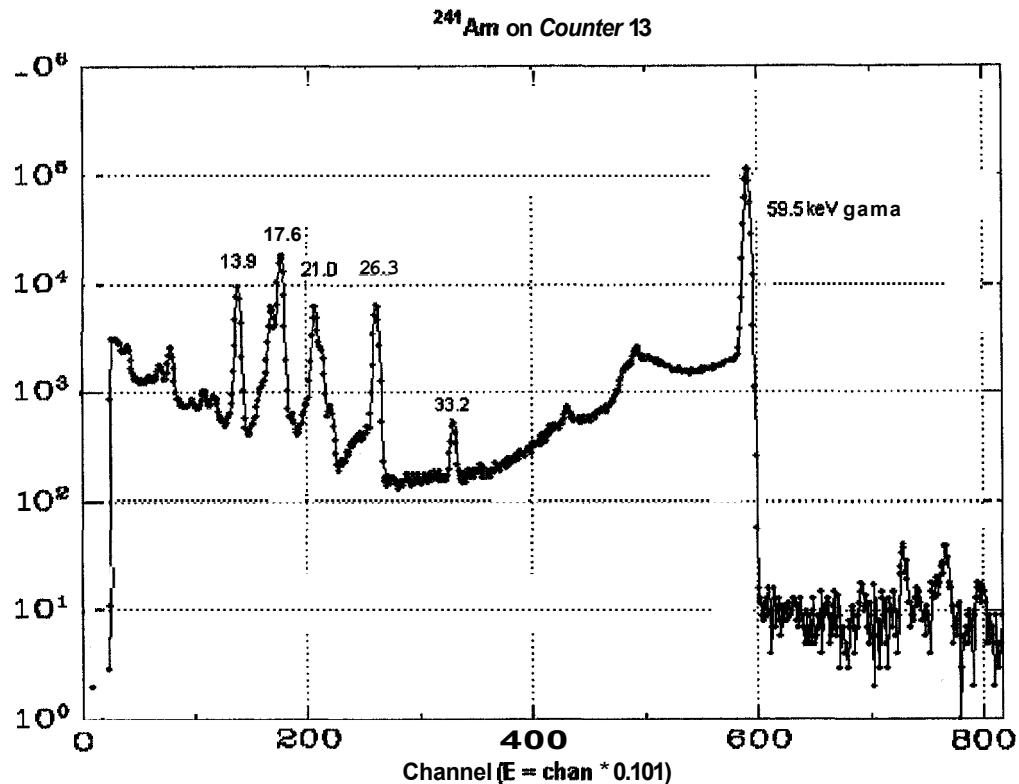


Figure 12 – Gamma and x-rays of  $^{241}\text{Am}$ .

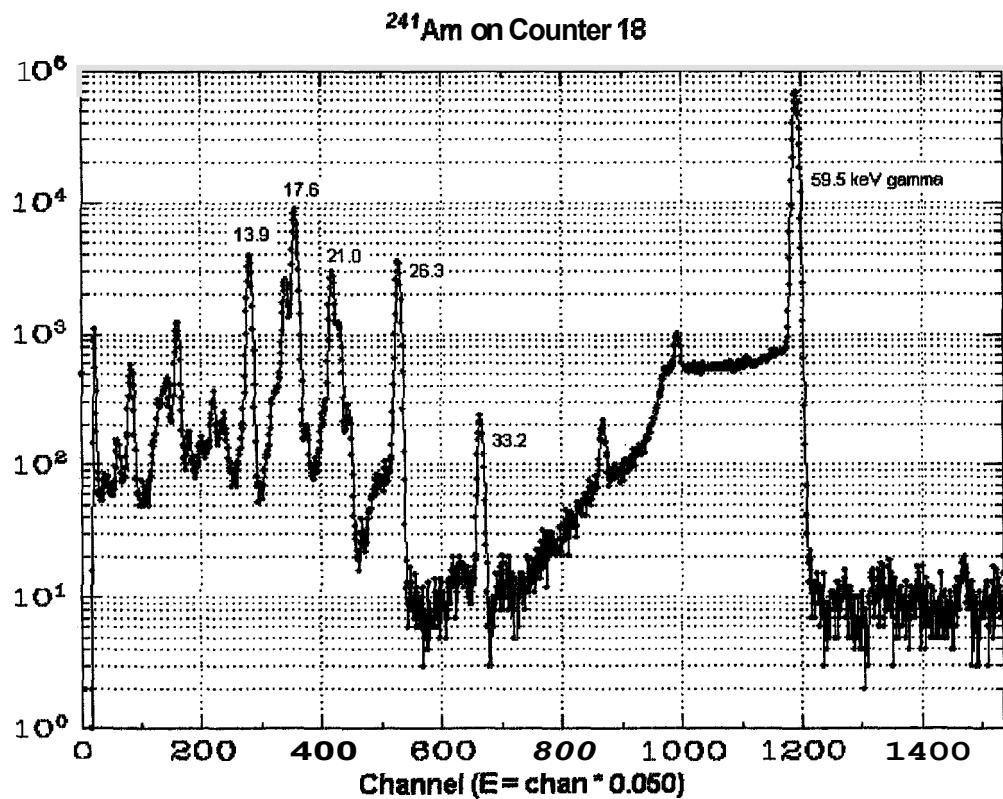


Figure 13 – Gamma and x-rays of  $^{241}\text{Am}$ .

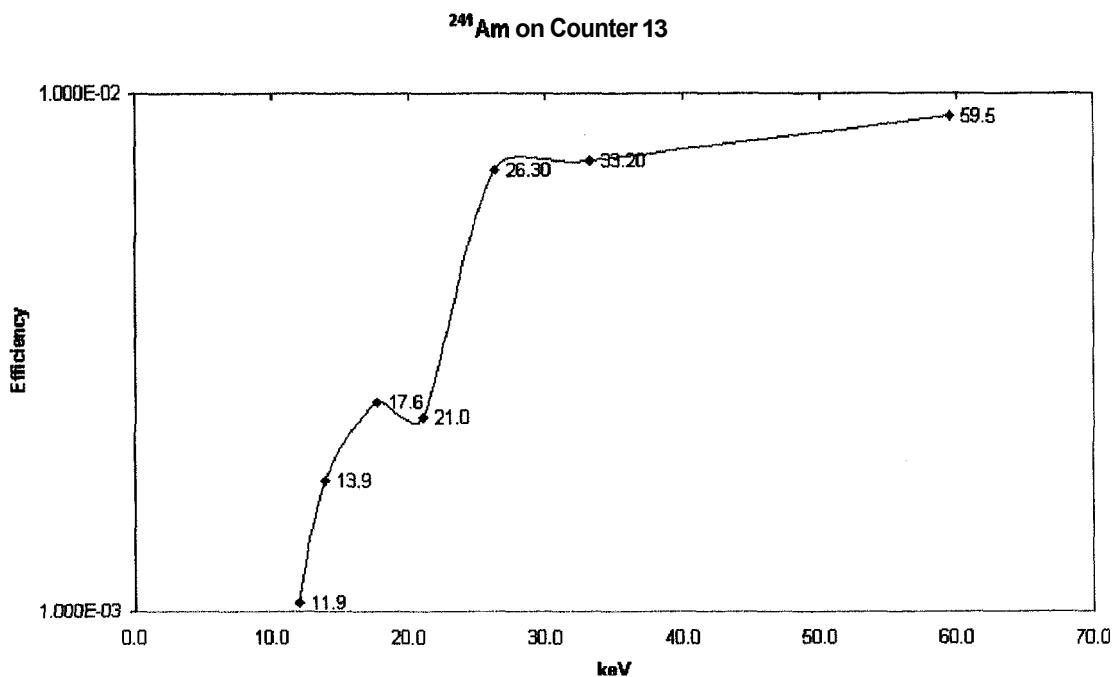
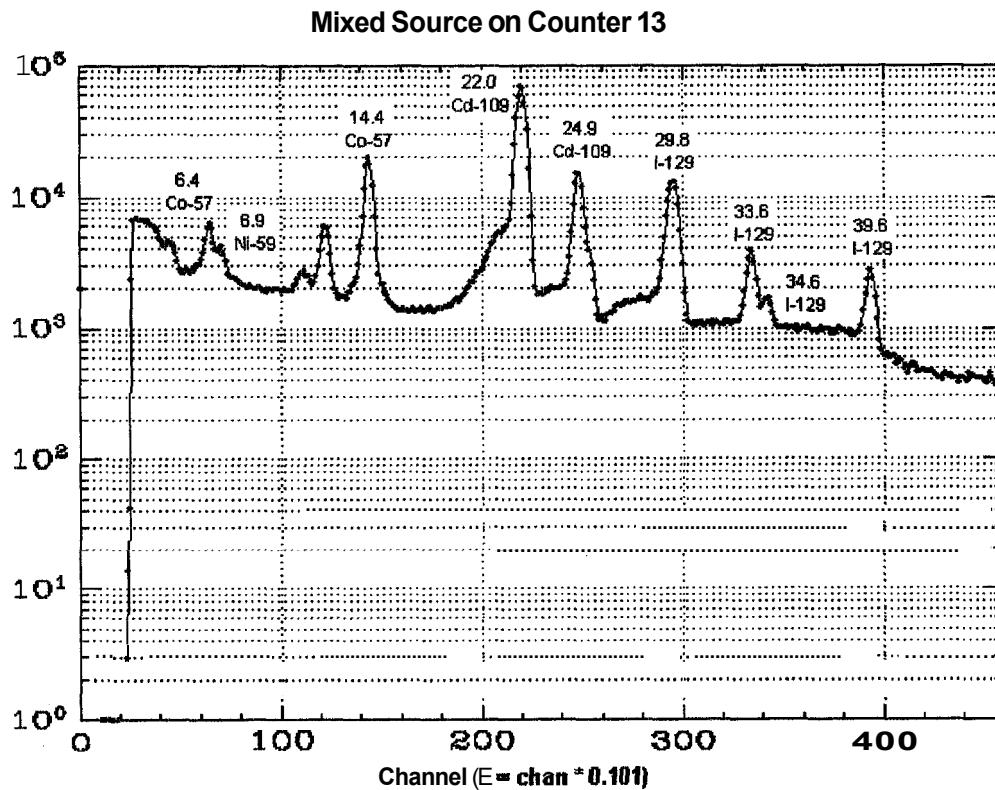


Figure 14 – Efficiency curve of counter 13 using  $^{241}\text{Am}$  emissions.

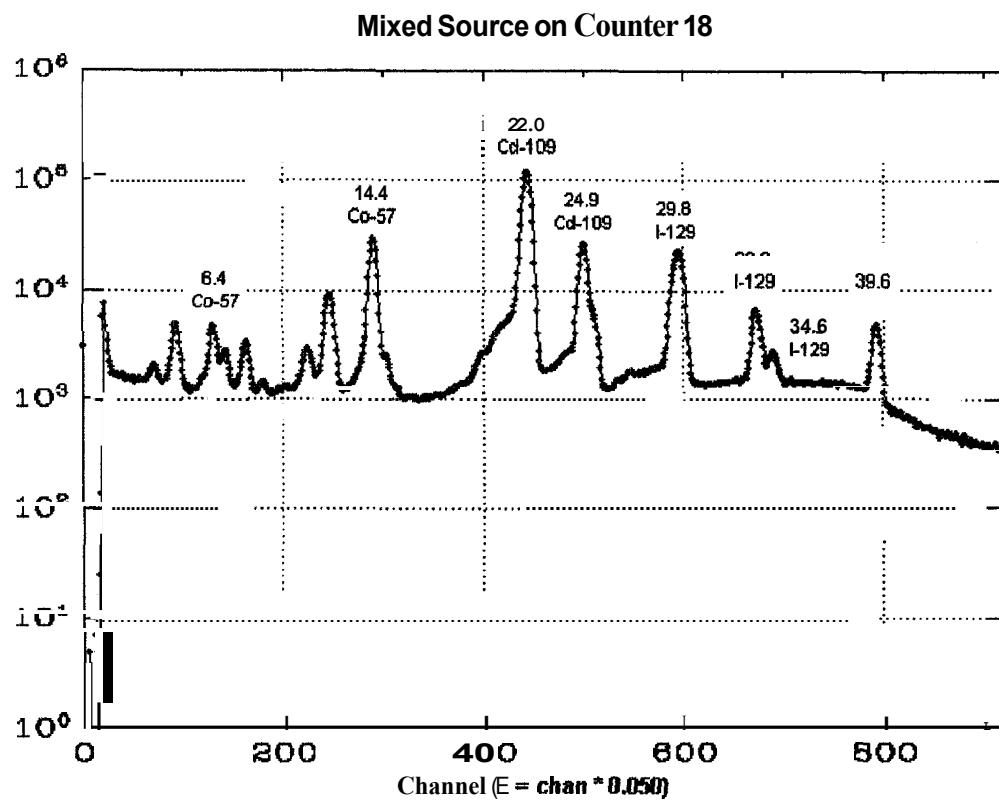
Figure 14 is the efficiency curve for counter 13 based on the  $^{241}\text{Am}$  standard **only**. This indicates that the 17.6 keV efficiency is overestimated, likely due to escape counts from the 26.3 peak.

#### IV. G. Mixed Source

The mixed isotope source was counted seven times on each of the counters **and** the raw counting data is included in Appendix G. Spectra from 0 keV to approximately 45 keV are illustrated in Figures 15 and 16 below. The low activities of  $^{59}\text{Ni}$  and  $^{55}\text{Fe}$  relative to the other isotopes makes their identification difficult in this source.



**Figure 15 – Low energy portion of mixed source**



**Figure 16 – Partial spectrum of the mixed source.**

## V. ATTACHMENTS

Appendix A –  $^{109}\text{Cd}$  Counting Data Summary

Appendix B –  $^{57}\text{Co}$  Counting Data Summary

Appendix C –  $^{59}\text{Ni}$  Counting Data Summary

Appendix D –  $^{55}\text{Fe}$  Counting Data Summary

Appendix E –  $^{129}\text{I}$  Counting Data Summary

Appendix F –  $^{241}\text{Am}$  Counting Data *Summary*

Appendix G – Mixed Source Counting Data Summary

Electronic files on CD

## **Appendix A**

### **$^{109}\text{Cd}$ Counting Data Summary**

### Cd-109 on Counter 13

<u>Standard</u>	<u>Referencedate</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Cd-109	336.5000 12/2/00 12:00 GMT	0.327 microcuries	462.59 days	21.99 22.163 24.934 25.6 88.03	0.289 0.545 0.137 0.0272 0.036

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
241-050	13	200	9	241.7938
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.15	3187		Ge escape from 22.1
	12.23	15743		Ge escape from 22.1
	13.96	487		Ge escape from 24.94
	15.04	2841		Ge escape from 24.94
	22.11	266831	2.204E-03	Ag K-alpha
	24.94	65735	3.305E-03	Ag K-beta
	88.08	19000	4.811E-03	E3 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
242-039	13	200	9	242.6114
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.15	3420		Ge escape from 22.1
	12.23	15583		Ge escape from 22.1
		not identified		Ge escape from 24.94
	15.04	2962		Ge escape from 24.94
	22.1	266131	2.198E-03	Ag K-alpha
	24.94	65891	3.313E-03	Ag K-beta
	88.05	19367	4.904E-03	E3 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
243-002	13	200	9	242.8804
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.12	3628		Ge escape from 22.1
	12.23	16240		Ge escape from 22.1
	13.93	323		Ge escape from 24.94
	15.06	2146		Ge escape from 24.94
	22.1	285113	2.355E-03	Ag K-alpha
	24.94	67794	3.408E-03	Ag K-beta
	88.04	19005	4.812E-03	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
243_032	13	200	9	243.5735
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.13	3488		Ge escape from 22.1
	12.22	16196		Ge escape from 22.1
	13.96	441		Ge escape from 24.94
	15.05	2822		Ge escape from 24.94
	22.11	264782	2.187E-03	Ag K-alpha
	24.94	65447	3.290E-03	Ag K-beta
	88.05	18746	4.747E-03	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
243-040	13	200	9	243.7127
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.16	3365		Ge escape from 22.1
	12.22	15977		Ge escape from 22.1
	14.02	421		Ge escape from 24.94
	15.09	2864		Ge escape from 24.94
	22.11	264623	2.185E-03	Ag K-alpha
	24.94	66291	3.333E-03	Ag K-beta
	88.05	18821	4.766E-03	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
244-001	13	200	9	243.8716
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.14	3286		Ge escape from 22.1
	12.22	15912		Ge escape from 22.1
	14.08	381		Ge escape from 24.94
	15.08	2615		Ge escape from 24.94
	22.1	264421	2.184E-03	Ag K-alpha
	24.94	65801	3.308E-03	Ag K-beta
	88.05	19106	4.838E-03	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
248-038	13	200	9	248.6053
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	11.15	3247		Ge escape from 22.1
	12.24	15804		Ge escape from 22.1
	13.99	833		Ge escape from 24.94
	15.11	3137		Ge escape from 24.94
	22.12	263498	2.176E-03	Ag K-alpha
	24.94	65314	3.284E-03	Ag K-beta
	88.04	18782	4.756E-03	E3 gamma

### Cd-109 on Counter 18

Standard	Reference date	Activity @ Ref	Half-life	Emissions	Abn
Cd-109	336.5000	0.327	462.59	21.99	0.269
	12/2/2000	microcuries	days	22.163	0.545
	12:00 GMT			24.934	0.137
				25.6	0.0272
				86.03	0.036

#### Count Summaries:

SN	Counter	CL (min)	Shelf	Count time
236-025	18	100	5	236.4472
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	6.38	926		Fe K-alpha
	8.03	2369		Cu K-alpha
	8.88	408		Cu K-beta
	11.11	3951		Ge escape from 22.1
	12.22	10438		Ge escape from 22.1
	14.16	422		Ge escape from 24.9
	15.07	3566		Ge escape from 24.9
	22.10	287282	4.745E-03	Ag K-alpha
	24.94	75196	6.308E-03	Ag K-beta
	88.00	26364	1.009E-02	E3 gamma
237-005	18	100	5	237.0674
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	6.45	833		Fe K-alpha
	8.06	2485		Cu K-alpha
	9.01	376		Cu K-beta
	11.13	3792		Ge escape from 22.1
	12.24	19666		Ge escape from 22.1
	13.97	449		Ge escape from 24.9
	15.07	3482		Ge escape from 24.9
	22.1	291554	4.816E-03	Ag K-alpha
	24.93	74153	6.221E-03	Ag K-beta
	86.03	26628	1.019E-02	E3 gamma
237_026	18	100	5	237.3774
	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
	6.38	911		Fe K-alpha
	8.05	2467		Cu K-alpha
	8.98	364		Cu K-beta
	11.11	4015		Ge escape from 22.1
	12.24	19673		Ge escape from 22.1
	13.93	492		Ge escape from 24.9
	15.06	3434		Ge escape from 24.9
	22.11	286677	4.735E-03	Ag K-alpha
	24.93	74536	6.253E-03	Ag K-beta
	88	26527	1.015E-02	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CT (min)</u>	<u>Shelf</u>	<u>Counttime</u>
238_023	18	100	5	238.3075

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.46	892		Fe K-alpha
8.11	2409		Cu K-alpha
		not identified	Cu K-beta
11.15	3826		Ge escape from 22.1
12.24	19329		Ge escape from 22.1
13.88	410		Ge escape from 24.9
15.05	3472		Ge escape from 24.9
22.11	286271	4.728E-03	Ag K-alpha
24.95	74351	6.238E-03	Ag K-beta
88.01	26217	1.003E-02	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
238_055	18	100	5	238.9277

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.41	928		Fe K-alpha
8.03	2428		Cu K-alpha
8.92	389		Cu K-beta
11.1	3681		Ge escape from 22.1
12.23	19240		Ge escape from 22.1
14.16	361		Ge escape from 24.9
15.05	3202		Ge escape from 24.9
22.11	286370	4.730E-03	Ag K-alpha
24.92	73170	6.138E-03	Ag K-beta
88.05	26353	1.008E-02	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count_time</u>
239-012	18	100	5	239.2380

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.35	875		Fe K-alpha
8	2564		Cu K-alpha
		not identified	Cu K-beta
11.11	3734		Ge escape from 22.1
12.21	18609		Ge escape from 22.1
13.92	440		Ge escape from 24.9
15.08	3371		Ge escape from 24.9
22.1	285925	4.723E-03	Ag K-alpha
24.93	75216	6.310E-03	Ag K-beta
87.97	28358	1.009E-02	E3 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count_time</u>
239-034	18	100	5	239.5461

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.42	836		Fe K-alpha
6.07	2451		Cu K-alpha
		not identified	Cu K-beta
11.16	3747		Ge escape from 22.1
12.23	19725		Ge escape from 22.1
13.98	354		Ge escape from 24.9
15.1	3422		Ge escape from 24.9
22.1	286546	4.733E-03	Ag K-alpha
24.93	73420	6.159E-03	Ag K-beta
88.09	26166	1.001E-02	E3 gamma

## **Appendix B**

### **$^{57}\text{Co}$ Counting Data Summary**

### Co-57 on Counter 13

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Co-57	226.7083 (8/14/01 12EST)	1.505 microcuries	271.77 days	6.391 6.404 7.058 14.41 122.06 136.47	0.164 0.325 0.058 0.0954 0.855 0.1069

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
248_043	13	100	9	248.8029
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.52    6555    Ge escape peak from 14.4
				6.42    11832    Fe K-alpha
				7.04    3049    Fe K-beta
				14.41    67984    M I gamma
				122.08    1104152    M1+E2 gamma
				136.49    117199    E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
248_048	13	100	9	248.9133
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.5    7010    Ge escape peak from 14.4
				6.41    14017    Fe K-alpha
				not identified    8.579E-05    Fe K-beta
				14.42    68198    M I gamma
				122.07    1104122    M1+E2 gamma
				136.48    117397    E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
249-005	13	100	9	248.9971
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.51    3766    Ge escape peak from 14.4
				6.42    14428    Fe K-alpha
				not identified    8.831E-05    Fe K-beta
				14.41    68396    M I gamma
				122.07    1104057    M1+E2 gamma
				136.49    117627    E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
249-009	13	100	9	249.0665

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
4.47	12777		Ge escape peak from 14.4
6.42	13145	8.046E-05	Fe K-alpha
			Fe K-beta
	not identified		
14.41	68200	2.140E-03	M I gamma
122.07	1105128	3.869E-03	M1+E2 gamma
136.49	116742	3.269E-03	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
249-014	13	100	9	249.136

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
4.47	13541		Ge escape peak from 14.4
6.41	10338	6.328E-05	Fe K-alpha
7.05	3055	1.576E-04	Fe K-beta
14.4	68343	2.144E-03	M I gamma
122.07	1104379	3.866E-03	M1+E2 gamma
136.5	117196	3.281E-03	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
249-018	13	100	9	249.2054

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
4.52	5674		Ge escape peak from 14.4
6.41	10218	6.254E-05	Fe K-alpha
7.04	3146	1.623E-04	Fe K-beta
14.41	67779	2.126E-03	M I gamma
122.07	1104779	3.867E-03	M1+E2 gamma
136.48	116724	3.268E-03	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
249-037	13	100	9	249.5799

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
4.46	6464		Ge escape peak from 14.4
6.41	12290	7.522E-05	Fe K-alpha
	not identified		Fe K-beta
14.41	68645	2.154E-03	M I gamma
122.08	1104984	3.868E-03	M1+E2 gamma
136.49	117244	3.283E-03	E2 gamma

### Co-57 on Counter 18

<u>Standard</u>	<u>Referencedate</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Co-57	226.7083 8/14/01 12:00 EST	1.505 microcuries	271.77 days	6.391 6.404 7.058 14.41 122.06 136.47	0.164 0.325 0.058 0.0954 0.855 0.1069

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
237-042	18	100	5	237.7580

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.45	2376		Ge escape peak from 14.4
4.53	15674		Ge escape peak from 14.4
6.41	10916	6.681E-05	Fe K-alpha
7.07	3190	1.646E-04	Fe K-beta
7.99	2830		Cu K-alpha
14.41	132512	4.157E-03	M I gamma
24.00	2583		
122.06	3678591	1.288E-02	M1+E2 gamma
136.48	419198	1.174E-02	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
238-012	18	100	5	238.0680

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.55	2176		Ge escape peak from 14.4
4.55	15599		Ge escape peak from 14.4
6.41	10958	6.707E-05	Fe K-alpha
7.06	2464	1.272E-04	Fe K-beta
8.06	2158		Cu K-alpha
14.42	131621	4.129E-03	M I gamma
24.16	2705		
122.07	3671423	1.285E-02	M1+E2 gamma
136.48	417824	1.170E-02	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
238-026	18	100	5	238.3780

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.39	2519		Ge escape peak from 14.4
4.53	15731		Ge escape peak from 14.4
6.39	10641	6.513E-05	Fe K-alpha
7.08	2849	1.470E-04	Fe K-beta
8.08	2112		Cu K-alpha
14.41	133680	4.194E-03	M I gamma
24.2	2325		
122.07	3677821	1.287E-02	M1+E2 gamma
136.48	417418	1.169E-02	E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Counttime</u>
238_042	18	100	5	238.6880
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.50	2380		Ge escape peak from 14.4	
4.55	16275		Ge escape peak from 14.4	
6.41	10712	6.557E-05	Fe K-alpha	
7.00	2750	1.419E-04	Fe K-beta	
8.08	2566		Cu K-alpha	
14.41	133353	4.184E-03	M I gamma	
24.20	2662			
222.05	3668120	1.284E-02	M1+E2 gamma	
136.45	417552	1.169E-02	E2 gamma	
<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
239-003	18	100	5	238.9982
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.49	2091		Ge escape peak from 14.4	
4.53	15323		Ge escape peak from 14.4	
6.39	11477	7.025E-05	Fe K-alpha	
7.02	3191	1.647E-04	Fe K-beta	
8	2636		Cu K-alpha	
14.4	132936	4.171E-03	M I gamma	
24.14	2333			
122.08	3666564	1.284E-02	M1+E2 gamma	
136.51	417361	1.169E-02	E2 gamma	
<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
239-020	18	100	5	239.3085
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.49	2617		Ge escape peak from 14.4	
4.54	16188		Ge escape peak from 14.4	
6.39	11085	6.785E-05	Fe K-alpha	
7.03	2948	1.521E-04	Fe K-beta	
8.07	2207		Cu K-alpha	
14.39	132194	4.147E-03	M I gamma	
24.14	2785			
122.05	3664836	1.283E-02	M1+E2 gamma	
136.46	416193	1.165E-02	E2 gamma	
<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
239_036	18	100	5	239.6185
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.46	2215		Ge escape peak from 14.4	
4.54	15640		Ge escape peak from 14.4	
6.39	10955	6.705E-05	Fe K-alpha	
7.04	2703	1.395E-04	Fe K-beta	
8.01	2299		Cu K-alpha	
14.4	133147	4.177E-03	M I gamma	
24.24	2628			
122.06	3662533	1.282E-02	M1+E2 gamma	
136.47	416827	1.167E-02	E2 gamma	

## **Appendix C**

### **$^{59}\text{Ni}$ Counting Data Summary**

## Ni-59 on Counter 13

<u>Standard</u>	<u>Referencedate</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Ni-59	215.7083 8/3/01 12:00 EST	0.422 microcuries	2.74E+07 days	6.915 6.93 7.65	0.099 0.196 0.0356
			<u>SN</u> 272-017	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.98 7.7	<u>Pk Area</u> 40508 9703
					<u>Efficiency</u> 1.466E-04 2.909E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 273-003	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.98 9259	<u>Pk Area</u> 39939 9259
					<u>Efficiency</u> 1.445E-04 2.776E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 273-034	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.97 7.67	<u>Pk Area</u> 39082 9152
					<u>Efficiency</u> 1.414E-04 2.744E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 274-018	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.97 7.67	<u>Pk Area</u> 38216 8698
					<u>Efficiency</u> 1.383E-04 2.608E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 275-007	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.97 7.68	<u>Pk Area</u> 37275 8899
					<u>Efficiency</u> 1.349E-04 2.668E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 275-043	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.97 7.67	<u>Pk Area</u> 36413 9090
					<u>Efficiency</u> 1.318E-04 2.726E-04
					<u>Type</u> Co K-alpha Co K-beta
			<u>SN</u> 276-017	<u>Counter</u> 13	<u>CL (min)</u> 1000
				<u>Energy</u> 6.97 7.68	<u>Pk Area</u> 35816 8751
					<u>Efficiency</u> 1.296E-04 2.624E-04
					<u>Type</u> Co K-alpha Co K-beta

### Ni-59 on Counter 18

<u>Standard</u>	<u>Referencedate</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Ni-59	215.7083 8/14/01 12:00 EST	0.422 microcuries	27400000 days	6.915 6.93 7.65	0.099 0.196 0.0356

#### Count Summaries:

<u>SN</u> <u>250_048</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 249.6987
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.93	56563	1.36E-04	Co K-alpha
7.64	15085	3.02E-04	Co K-beta

<u>SN</u> <u>254_039</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 253.7548
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.93	56572	1.36E-04	Co K-alpha
7.65	15019	3.00E-04	Co K-beta

<u>SN</u> <u>260_015</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 258.1758
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.94	56659	1.37E-04	Co K-alpha
7.65	14986	3.00E-04	Co K-beta

<u>SN</u> <u>262-038</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 261.8484
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.95	56794	1.37E-04	Co K-alpha
7.66	14993	3.00E-04	Co K-beta

<u>SN</u> <u>265-001</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 263.9673
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.92	56911	1.37E-04	Co K-alpha
7.64	15325	3.06E-04	Co K-beta

<u>SN</u> <u>267-005</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 266.0862
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.92	56389	1.36E-04	Co K-alpha
7.65	15188	3.04E-04	Co K-beta

<u>SN</u> <u>269-012</u>	<u>Counter</u> 18	<u>CL (min)</u> 1500	<u>Shelf</u> 5	<u>Count time</u> 268.2051
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<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
6.94	57135	1.38E-04	Co K-alpha
7.66	14563	2.91E-04	Co K-beta

## **Appendix D**

### **$^{55}\text{Fe}$ Counting Data Summary**

## **Fe-55 on Counter 13**

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Fe-55	229.7083 8/17/01 12:00 EST	0.510 microcuries	997.13 days	5.888 5.899 6.49	0.082 0.162 0.0286

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
277-011	13	1000	9	276.7468

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
5.94	14956	4.846E-05	Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
278-006	13	1000	9	276.44 14

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
5.94	12551	4.543E-05	Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
278_037	13	1000	9	278.1380

Energy    Pk Area    Efficiency    Type  
5.93        10638        3.851E-05      Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
279-020	13	1000	9	278.8306

Energy    Pk Area    Efficiency    Type  
5.94        9546        3.455E-05    Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Counttime</u>
280-010	13	1000	9	279.5251

Energy    Pk Area    Efficiency    Type  
5.94        8582        3.107E-05    Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Counttime</u>
280_033	13	1000	9	280.2197

Energy    Pk Area    Efficiency    Type  
5.94        8312        3.009E-05    Mn K-alpha

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
281-018	13	1000	9	280.9143

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
5.94	8435	3.053E-05	Mn K-alpha

### Fe-55 on Counter 18

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Fe-55	229.7083	0.510	997.13	5.888	0.082
	8/17/01	microcuries	days	5.899	0.162
	12:00 EST			6.49	0.0286

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
253_031	18	1500	5	250.8436
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.90	13536	3.27E-05	Mn K-alpha
	6.46	4283	8.82E-05	Mn K-beta
255_041	18	1500	5	254.8013
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.91	13237	3.19E-05	Mn K-alpha
	6.49	4480	9.22E-05	Mn K-beta
261_030	18	1500	5	260.7759
	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
	5.91	13245	3.20E-05	Mn K-alpha
	6.50	4392	9.04E-05	Mn K-beta
263_063	18	1500	5	262.8949
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.90	13521	3.26E-05	Mn K-alpha
	6.51	4327	8.91E-05	Mn K-beta
266-003	18	1500	5	265.0138
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.88	13202	3.19E-05	Mn K-alpha
	6.47	4292	8.84E-05	Mn K-beta
268-013	18	1500	5	267.1327
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.89	13287	3.21E-05	Mn K-alpha
	6.48	4301	8.86E-05	Mn K-beta
270-014	18	1500	5	269.2516
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	5.90	12984	3.13E-05	Mn K-alpha
	6.48	4029	8.30E-05	Mn K-beta

## **Appendix E**

### **$^{129}\text{I}$ Counting Data Summary**

### I-129 on Counter 13

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
1-129	250.7083 9/7/01 12:00 EST	0.457 microcuries	5.73E+09 days	29.461 29.782 33.606 34.806 39.571	0.204 0.378 0.102 0.0242 0.075

Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
267-046	13	60	9	267.9009
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.69	1314		Ge escape from 29.7
	19.82	6659		Ge escape from 29.7
	not identified			
	29.72	243077	6.861E-03	Xe K-alpha
	32.36	2599		
	33.63	57413	9.247E-03	Xe K-beta
	34.43	13017	8.836E-03	Xe K-beta
	39.60	28052	6.144E-03	M1+E2 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
268-032	13	60	9	268.5203
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.8	1306		Ge escape from 29.7
	19.83	6630		Ge escape from 29.7
	24.72	1600		
	29.71	259226	7.317E-03	Xe K-alpha
	not identified			
	33.62	39260	6.323E-03	Xe K-beta
	34.43	8976	6.093E-03	Xe K-beta
	39.60	28225	6.182E-03	M1+E2 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
268-038	13	60	9	268.6108
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.77	1442		Ge escape from 29.7
	19.82	6854		Ge escape from 29.7
	23.79	2075		
	29.7	259923	7.337E-03	Xe K-alpha
	not identified			
	33.62	39521	6.365E-03	Xe K-beta
	34.44	8994	6.105E-03	Xe K-beta
	39.61	28635	6.272E-03	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
268-042	13	60	9	268.6679
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.77	1480		Ge escape from 29.7
	19.84	6457		Ge escape from 29.7
	27.81	13179		
	29.71	235886	6.658E-03	Xe K-alpha
	31.66	2.057E+03		
	33.62	56534	9.105E-03	Xe K-beta
	34.42	13603	9.234E-03	Xe K-beta
	39.60	28362	6.212E-03	M1+E2 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
268-051	13	60	9	268.7098
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.73	1363		Ge escape from 29.7
	19.82	6734		Ge escape from 29.7
	24.76	1778		
	29.71	259526	7.326E-03	Xe K-alpha
	<b>not identified</b>			
	33.62	39213	6.316E-03	Xe K-beta
	34.43	8991	6.103E-03	Xe K-beta
	39.60	28638	6.273E-03	M1+E2 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
268-057	13	60	9	268.7602
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.74	1369		Ge escape from 29.7
	19.8	6572		Ge escape from 29.7
	28.16	13103		
	29.68	209529	5.914E-03	Xe K-alpha
	<b>not identified</b>			
	33.63	39069	6.292E-03	Xe K-beta
	34.43	9275	6.296E-03	Xe K-beta
	39.61	28596	6.264E-03	M1+E2 gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
269-031	13	60	9	269.5886
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	18.75	1510		Ge escape from 29.7
	19.84	6518		Ge escape from 29.7
	27.81	13245		
	29.72	245910	6.941E-03	Xe K-alpha
	<b>not identified</b>			
	33.63	39530	6.367E-03	Xe K-beta
	34.43	9158	6.217E-03	Xe K-beta
	39.61	28575	6.259E-03	M1+E2 gamma

### I-129 on Counter 18

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
I-129	250.7083 9/7/01 12:00 EST	0.457 microcuries	5.73E+09 days	29.461 29.782 33.606 34.606 39.571	0.204 0.378 0.102 0.0242 0.075

Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
271-037	18	150	5	267.9009
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	6.42	2175		Fe K-alpha
	8.06	7560		Cu K-alpha
	8.92	1300		Cu K-beta
	18.78	11192		Ge escape from 29.7
	19.84	50108		Ge escape from 29.7
	22.7	996		Ge escape from 33.6
	23.73	5548		Ge escape from 33.6
	24.57	624		Ge escape from 34.4
	27.34	27134		edge from 29.7
	29.74	1207790	1.364E-02	Xe K-alpha
	32.30	2003		edge from 33.6
	33.61	240783	1.551E-02	Xe K-beta
	34.42	56468	1.533E-02	Xe K-beta
	39.59	172995	1.516E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count_time</u>
272-007	18	150	5	272.0035
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	6.37	2056		Fe K-alpha
	8.03	7318		Cu K-alpha
	8.90	1300		Cu K-beta
	18.71	10901		Ge escape from 29.7
	19.83	47934		Ge escape from 29.7
	22.59	798		Ge escape from 33.6
	23.72	5626		Ge escape from 33.6
	24.66	651		Ge escape from 34.4
	27.84	11429		edge from 29.7
	29.72	1211978	1.368E-02	Xe K-alpha
	32.71	2002		edge from 33.6
	33.60	240301	1.549E-02	Xe K-beta
	34.41	56585	1.536E-02	Xe K-beta
	39.58	174139	1.526E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count_time</u>
272-026	18	150	5	272.3525
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	6.37	1924		Fe K-alpha
	8.04	7565		Cu K-alpha
	8.96	1411		Cu K-beta
	18.72	10416		Ge escape from 29.7
	19.84	46701		Ge escape from 29.7
	22.63	940		Ge escape from 33.6
	23.69	5844		Ge escape from 33.6
	24.67	758		Ge escape from 34.4
	27.54	31506		edge from 29.7
	29.71	1334820	1.507E-02	Xe K-alpha
	not identified			edge from 33.6
	33.60	237129	1.528E-02	Xe K-beta
	34.40	57287	1.556E-02	Xe K-beta
	39.57	173938	1.524E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>Cl_(min)</u>	<u>Shelf</u>	<u>Count time</u>
272-041	18	150	5	272.7015
				<b>Type:</b>
	<b>Energy</b>	<b>Pk Area</b>	<b>Efficiency</b>	
	6.41	1986		Fe K-alpha
	8.03	7197		Cu K-alpha
	8.96	1170		Cu K-beta
	18.74	10811		Ge escape from 29.7
	19.84	48353		Ge escape from 29.7
	22.67	930		Ge escape from 33.6
	23.68	5610		Ge escape from 33.6
		not identified		Ge escape from 34.4
	27.89	13367		edge from 29.7
	29.72	1214706	1.371E-02	Xe K-alpha
		not identified		edge from 33.6
	33.60	240285	1.548E-02	Xe K-beta
	34.42	57553	1.563E-02	Xe K-beta
	39.58	174772	1.531E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>Cl_(min)</u>	<u>Shelf</u>	<u>Count time</u>
273-009	18	150	5	273.0503
				<b>Type:</b>
	<b>Energy</b>	<b>Pk Area</b>	<b>Efficiency</b>	
	6.39	1727		Fe K-alpha
	8.03	7641		Cu K-alpha
	8.07	1428		Cu K-beta
	18.74	11252		Ge escape from 29.7
	19.84	47669		Ge escape from 29.7
	22.57	1038		Ge escape from 33.6
	23.70	5549		Ge escape from 33.6
		not identified		Ge escape from 34.4
	27.77	31903		edge from 29.7
	29.71	1333546	1.506E-02	Xe K-alpha
		not identified		edge from 33.6
	33.59	240614	1.550E-02	Xe K-beta
	34.41	56598	1.537E-02	Xe K-beta
	39.59	174307	1.527E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>Cl_(min)</u>	<u>Shelf</u>	<u>Count time</u>
273-024	18	150	5	273.3990
				<b>Type:</b>
	<b>Energy</b>	<b>Pk Area</b>	<b>Efficiency</b>	
	6.45	2171		Fe K-alpha
	8.03	7336		Cu K-alpha
	8.97	1067		Cu K-beta
	18.74	11092		Ge escape from 29.7
	19.06	47968		Ge escape from 29.7
	22.72	1048		Ge escape from 33.6
	23.73	5812		Ge escape from 33.6
	24.64	728		Ge escape from 34.4
	27.69	31507		edge from 29.7
	29.72	1333631	1.506E-02	Xe K-alpha
	32.51	1365		edge from 33.6
	33.60	239019	1.540E-02	Xe K-beta
	34.41	56378	1.531E-02	Xe K-beta
	39.57	174377	1.528E-02	M1+E2 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
274-030	18	150	5	273.7480
		<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
		6.37	1941	Fe K-alpha
		8.04	7538	Cu K-alpha
		8.82	1222	Cu K-beta
		18.79	10695	Ge escape from 29.7
		19.84	48099	Ge escape from 29.7
		22.67	966	Ge escape from 33.6
		23.74	5803	Ge escape from 33.6
		24.64	643	Ge escape from 34.4
		not included		
		29.71	1448669	edge from 29.7
		32.45	1627	Xe K-alpha
		33.60	241745	edge from 33.6
		34.41	57091	Xe K-beta
		39.57	173700	Xe K-beta
				M1+E2 gamma

## **Appendix F**

### **$^{241}\text{Am}$ Counting Data Summary**

### Am-241 on Counter 13

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Am-241	255.0000 9/12/2001 00:00 GMT	0.936 microcuries	1.58E+05 days	11.871 13.927 17.611 20.997 26.34 33.192 43.42 59.54	0.0081 0.13 0.202 0.052 0.024 0.0012 0.00073 0.357

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
282_042	13	100	9	282.8088
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	4.13	2848		Ge escape from 14.0
	6.99	2833		Ge escape from 16.9
	7.90	8567		Cu K-alpha
	10.95	1969		Ge escape from 20.8
	11.83	1752	1.041E-03	Np L
	13.97	47223	1.748E-03	Np L-alpha
	16.97	32924		
	17.78	102459	2.441E-03	Np L-beta
	20.85	45078	4.172E-03	Np L-gamma
	22.25	3784		
	24.84	1058		edge from 26.3
	26.38	34648	6.948E-03	E I gamma
	33.23	1959	7.856E-03	M1+E2 gamma
	43.47	2057	1.356E-02	M1+E2 gamma
	49.75	40999		Ge escape from 59.5
	59.63	630486	8.499E-03	E I gamma
	73.59	172		
	99.16	323		
	103.21	275		E I gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
283_002	13	100	9	282.9434
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	4.06	3215		Ge escape from 14.0
	7.00	3126		Ge escape from 16.9
	7.91	0887		Cu K-alpha
	10.93	1355		Ge escape from 20.8
	11.89	1566	9.304E-04	Np L
	13.96	48313	1.789E-03	Np L-alpha
	16.97	33442		
	17.77	104299	2.485E-03	Np L-beta
	20.83	46104	4.267E-03	Np L-gamma
	22.22	4090		
	24.42	771		edge from 26.3
	26.37	34895	6.997E-03	E I gamma
	33.21	1783	7.151E-03	M1+E2 gamma
	43.51	2155	1.421E-02	M1+E2 gamma
	56.05	6411		edge from 59.5
	56.96	7047		edge from 59.5
	57.79	7925		edge from 59.5
	59.62	699862	9.434E-03	E I gamma
	73.70	163		
	77.40	166		
	99.12	271		
	103.10	262		E I gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
283_003	13	100	9	283.0132
<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>		
4.05	3419	Ge escape from 14.0		
6.99	3061	Ge escape from 16.9		
7.88	8919	Cu K-alpha		
10.91	1679	Ge escape from 20.8		
11.83	1900	1.129E-03 Np L		
13.96	47994	1.777E-03 Np L-alpha		
16.96	32235			
17.77	103239	2.460E-03 Np L-beta		
20.83	43972	4.070E-03 Np L-gamma		
22.20	3647			
26.37	35611	7.141E-03 E1 gamma		
33.25	1779	7.135E-03 M1+E2 gamma		
43.46	2143	1.413E-02 M1+E2 gamma		
49.77	37858	Ge escape from 59.5		
59.63	636188	8.576E-03 E1 gamma		
99.11	310			
103.23	255	E1 gamma		

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
283_008	13	100	9	283.0830
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.10	3387	Ge escape from 14.0		
7.00	2917	Ge escape from 16.9		
7.89	8219	Cu K-alpha		
10.89	1347	Ge escape from 20.8		
11.86	1436	8.532E-04 Np L		
13.96	48480	1.795E-03 Np L-alpha		
16.96	32822			
17.77	104580	2.492E-03 Np L-beta		
20.83	45949	4.252E-03 Np L-gamma		
22.20	4107			
26.37	36304	7.280E-03 E1 gamma		
33.21	1773	7.110E-03 M1+E2 gamma		
43.47	2299	1.516E-02 M1+E2 gamma		
49.71	41202	Ge escape from 59.5		
59.62	637822	8.598E-03 E1 gamma		
77.46	151			
99.12	279			
103.14	319	E1 gamma		

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
283-010	13	100	9	283.1527
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.06	5181	Ge escape from 14.0		
8.98	3392	Ge escape from 16.9		
7.90	8664	Cu K-alpha		
10.89	1199	Ge escape from 20.8		
11.89	1321	7.849E-04 Np L		
13.95	48434	1.793E-03 Np L-alpha		
16.96	33391			
17.77	104076	2.480E-03 Np L-beta		
20.83	46407	4.295E-03 Np L-gamma		
22.22	4027			
25.41	1190	edge from 26.4		
26.37	34817	6.982E-03 E1 gamma		
33.23	1864	7.475E-03 M1+E2 gamma		
42.30	843	edge from 43.4		
43.42	2200	1.450E-02 M1+E2 gamma		
59.62	729633	9.836E-03 E1 gamma		
77.54	253			
99.18	273			
103.10	318	E1 gamma		

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
283_013	13	100	9	283.2225
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.10    4866
				7.01    2875
				7.89    8662
				10.95    2031
				11.82    2156    1.281E-03    Np L
				13.95    48575    1.798E-03    Np L-alpha
				16.96    33078
				17.77    105083    2.504E-03    Np L-beta
				20.82    45946    4.252E-03    Np L-gamma
				22.19    4177
				26.37    36392    7.297E-03    E I gamma
				33.22    1874    7.516E-03    M1+E2 gamma
				42.02    709    edge from 43.4
				43.45    2800    1.846E-02    M1+E2 gamma
				49.78    40155
				53.50    967
				59.62    641250    8.644E-03    E I gamma
				77.44    166
				99.22    287
				103.19    273
				E I gamma
<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
283_016	13	100	9	283.2923
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.07    3436
				6.97    3098
				7.88    8860
				10.91    1873
				11.88    2116    1.257E-03    Np L
				13.95    48630    1.800E-03    Np L-alpha
				16.96    35890
				17.77    116129    2.767E-03    Np L-beta
				20.82    39428    3.649E-03    Np L-gamma
				22.20    3233
				26.37    36222    7.263E-03    E I gamma
				33.23    1909    7.656E-03    M1+E2 gamma
				43.51    1754    1.156E-02    M1+E2 gamma
				56.61    7181    edge from 59.6
				59.62    722413    9.738E-03    E I gamma
				69.93    151
				99.26    289
				103.18    270
				E I gamma

### Am-241 on Counter 18

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life</u>	<u>Emissions</u>	<u>Abn</u>
Am-241	255.0000 9/12/2001 00:00 GMT	0.936 microcuries	1.58E+05 days	11.871 13.927 17.611 20.997 26.34 33.192 43.42 59.54	0.0081 0.13 0.202 0.052 0.024 0.0012 0.00073 0.357

#### Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
		50	5	
276_036	18			276.6924
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.00	566		Ge escape from 14.0	
4.06	4435		Ge escape from 14.0	
7.05	4531		Ge escape from 16.9	
7.88	14353		Cu K-alpha	
8.96	560		Cu K-beta	
10.97	2192		Ge escape from 20.8	
11.84	1530	1.818E-03	Np L	
13.98	35771	2.648E-03	Np L-alpha	
16.94	26207			
17.75	90055	4.291E-03	Np L-beta	
18.74	1020			
20.79	40041	7.411E-03	Np L-gamma	
22.17	3528			
24.55	508		edge from 26.3	
25.18	660		edge from 26.3	
26.34	33084	1.327E-02	E I gamma	
33.21	2004	1.607E-02	M1+E2 gamma	
43.44	1376	1.814E-02	M1+E2 gamma	
48.67	1712		Ge escape from 59.5	
49.69	4883		Ge escape from 59.5	
59.53	716284	1.931E-02	E I gamma	
103.02	369		E I gamma	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
276_048	18	50	5	276.825
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.01	651		Ge escape from 14.0	
4.06	4309		Ge escape from 14.0	
6.94	3304		Ge escape from 16.9	
7.92	10599		Cu K-alpha	
8.74	527		Cu K-beta	
10.93	2607		Ge escape from 20.8	
11.78	1573	1.869E-03	Np L	
13.94	35818	2.652E-03	Np L-alpha	
16.92	26565			
17.75	90015	4.289E-03	Np L-beta	
18.84	805			
20.8	42587	7.883E-03	Np L-gamma	
22.2	3768			
24.43	379		edge from 26.3	
24.89	617		edge from 26.3	
25.3	377		edge from 26.3	
25.63	898		edge from 26.3	
26.34	32172	1.290E-02	E I gamma	
33.25	1908	1.530E-02	M1+E2 gamma	
43.43	1147	1.512E-02	M1+E2 gamma	
48.57	1853		Ge escape from 59.5	
49.65	4678		Ge escape from 59.5	
59.53	717263	1.934E-02	E I gamma	
102.78	158		E I gamma	
103.17	239		poorly shaped peak	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
277-029	18	50	5	276.6442
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.06	4529		Ge escape from 14.0	
6.45	2491		Fe K-alpha	
6.97	3752		Ge escape from 16.9	
7.93	11700		Cu K-alpha	
10.86	2220		Ge escape from 20.8	
11.83	1432	1.702E-03	Np L	
13.96	35891	2.657E-03	Np L-alpha	
16.94	26244			
17.76	89106	4.246E-03	Np L-beta	
18.73	1152			
20.81	42382	7.845E-03	Np L-gamma	
22.22	3645			
24.16	469		edge from 26.3	
24.91	655		edge from 26.3	
26.35	33534	1.345E-02	E I gamma	
33.17	1995	1.600E-02	M1+E2 gamma	
43.40	1568	2.067E-02	M1+E2 gamma	
49.62	4373		Ge escape from 59.5	
59.53	716823	1.933E-02	E I gamma	
98.97	388		E2 gamma	
103.13	316		E I gamma	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
277_033	18	50	5	277.7240

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.04	466		Ge escape from 14.0
4.09	4361		Ge escape from 14.0
6.44	2623		Fe K-alpha
6.99	3707		Ge escape from 16.9
7.93	11538		Cu K-alpha
10.93	2306		Ge escape from 20.8
11.81	1526	1.813E-03	Np L
13.94	36540	2.705E-03	Np L-alpha
16.93	26696		
17.76	90383	4.307E-03	Np L-beta
18.69	1172		
20.80	43055	7.969E-03	Np L-gamma
22.20	3728		
24.50	488		edge from 26.3
25.25	705		edge from 26.3
26.34	33624	1.348E-02	E1 gamma
33.20	1952	1.566E-02	M1+E2 gamma
43.38	1231	1.623E-02	M1+E2 gamma
48.70	1423		Ge escape from 59.5
49.69	4611		Ge escape from 59.5
59.53	719678	1.940E-02	E1 gamma
99.08	361		E2 gamma
103.09	393		E1 gamma

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
278_013	18	50	5	278.4839

<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.02	556		Ge escape from 14.0
4.06	4601		Ge escape from 14.0
6.92	4454		Ge escape from 16.9
7.93	13202		Cu K-alpha
10.92	2342		Ge escape from 20.8
11.91	1591	1.891E-03	Np L
13.96	36085	2.672E-03	Np L-alpha
16.92	25854		
17.75	89908	4.284E-03	Np L-beta
18.73	1146		
20.80	42291	7.828E-03	Np L-gamma
22.20	3981		
24.58	408		edge from 26.3
25.04	726		edge from 26.3
26.34	33568	1.346E-02	E1 gamma
33.18	1991	1.597E-02	M1+E2 gamma
43.39	1270	1.674E-02	M1+E2 gamma
48.64	3892		Ge escape from 59.5
49.61	9624		Ge escape from 59.5
50.59	2101		
58.67	1097		
59.53	715596	1.929E-02	E1 gamma
99.09	288		E2 gamma
103.04	346		E1 gamma

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
279_009	18	50	5	279.2438
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
3.04	601			Ge escape from 14.0
4.06	4471			Ge escape from 14.0
6.40	2614			Fe K-alpha
6.89	3714			Ge escape from 16.9
7.91	12036			Cu K-alpha
10.84	1438			Ge escape from 20.8
11.96	1022	1.214E-03	Np L	
13.96	35567	2.633E-03	Np L-alpha	
16.92	26207			
17.75	89724	4.275E-03	Np L-beta	
18.74	1101			
20.15	2352			
20.78	39873	7.380E-03	Np L-gamma	
22.21	3375			
24.17	459			edge from 26.3
25.04	600			edge from 26.3
26.34	33477	1.343E-02	E I gamma	
33.19	1998	1.603E-02	M1+E2 gamma	
43.45	1563	2.061E-02	M1+E2 gamma	
49.67	4964			Ge escape from 59.5
59.53	717889	1.935E-02	E I gamma	
98.95	282			E2 gamma
102.87	292			E I gamma

<u>SN</u>	<u>Counter</u>	<u>CL(min)</u>	<u>Shelf</u>	<u>Count time</u>
280_004	18	50	5	280.0039
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
2.99	694			Ge escape from 14.0
4.09	4659			Ge escape from 14.0
6.41	2546			Fe K-alpha
6.97	4001			Ge escape from 16.9
7.93	11586			Cu K-alpha
10.89	2311			Ge escape from 20.8
11.81	1174	1.395E-03	Np L	
13.95	36349	2.691E-03	Np L-alpha	
16.92	26682			
17.76	90103	4.293E-03	Np L-beta	
18.70	1245			
20.18	2162			
20.79	40127	7.427E-03	Np L-gamma	
22.20	3341			
23.72	281			edge from 26.3
24.48	501			edge from 26.3
24.98	299			edge from 26.3
25.28	745			edge from 26.3
26.33	33212	1.332E-02	E I gamma	
33.17	1973	1.583E-02	M1+E2 gamma	
43.46	1107	1.460E-02	M1+E2 gamma	
48.63	1440			Ge escape from 59.5
49.63	4947			Ge escape from 59.5
59.53	718027	1.936E-02	E I gamma	
98.93	349			E2 gamma
102.93	271			E I gamma

**Appendix *G***

**Mixed Source Counting Data Summary**

## Mixed Source on Counter 13

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life (d)</u>	<u>Emissions</u>	<u>Abs</u>
Fe-55	229.7083	0.467	997.13	5.888	0.082
				5.899	0.162
				6.49	0.0286
Ni-59	215.7083	0.260	<b>2.74E+07</b>	6.915	0.099
				6.93	0.196
				7.65	0.0356
Co-57	226.7083	1.034	271.77	6.391	0.164
				6.404	0.325
				7.058	0.058
Cd-109	336.5000	0.325	462.59	14.41	0.0954
				122.06	0.855
				136.47	0.1069
I-129	250.7083	0.053	<b>5.73E+09</b>	21.99	0.289
				22.163	0.545
				24.934	0.137
				25.6	0.0272
				88.03	0.036
				29.461	0.204
				29.782	0.378
				33.606	0.102
				34.606	0.0242
				39.571	0.075

## Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
283_034	13	200	5	283.6270
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.48	2494		Ge escape from	14.1
6.43	17267	7.691E-05	Fe K-alpha-1&2	
7.01	7896	2.319E-04	Co K-x-rays	
11.14	4046		Ge escape from	22.1
12.52	25330		Ge escape from	22.1
14.43	94199	2.151E-03	M1 from Co-57	
22.13	433516	3.605E-03	Ag K-alpha-1&2	
24.98	83280	4.211E-03	Ag K-beta-1&2	
27.42	2431		edge from 29.7	
29.74	87130	6.422E-03	Xe K-alpha 1&2	
33.66	15070	6.338E-03	Xe K-beta 1	
34.44	3499	6.203E-03	<b>Xe K-beta 2</b>	
39.63	10545	6.032E-03	M1 + E2 from 1-129	
84.58	14248		edge from 122	
85.78	9260		edge from 122	
88.17	17773	3.424E-03	E3 from Cd-109	
122.26	1411638	3.596E-03	M1+E2 from Co-57	
136.70	749690	3.050E-03	<b>E2 from Co-57</b>	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
283-039	13	200	5	283.7668
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				6.43    25397    1.131E-04    Fe K-alpha-1&2
				not identified    0.000E+00    Co Kx-rays
				11.14    4304    Ge escape from 22.1
				12.44    25526    Ge escape from 22.1
				14.43    94345    2.154E-03    M I from Co-57
				22.13    409301    3.404E-03    Ag K-alpha-1&2
				24.96    84605    4.283E-03    Ag K-beta-1&2
				27.83    3672    edge from 29.7
				29.74    89263    6.580E-03    Xe K-alpha 1&2
				33.65    15177    6.383E-03    Xe K-beta 1
				34.47    3577    Xe K-beta 2
				39.65    10808    6.182E-03    M1 + E2 from 1-129
				84.98    20398    edge from 122
				88.17    62523    1.204E-02    E3 from Cd-109
				122.26    1412140    3.598E-03    M1+E2 from Co-57
				136.70    149973    3.056E-03    E2 from Co-57

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
284_001	13	200	5	283.9066
				<u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.41    44584    Ge escape from 14.1
				6.43    17177    7.651E-05    Fe K-alpha-1&2
				6.97    7958    Co Kx-rays
				11.15    5170    Ge escape from 22.1
				12.23    23397    Ge escape from 22.1
				14.42    93454    2.134E-03    M I from Co-57
				22.12    408811    3.399E-03    Ag K-alpha-1&2
				24.96    84815    4.293E-03    Ag K-beta-1&2
				29.73    92087    6.788E-03    Xe K-alpha 1&2
				33.64    15361    6.461E-03    Xe K-beta 1
				34.46    3801    Xe K-beta 2
				39.64    10946    6.261E-03    M I + E2 from I-129
				85.03    20229    edge from 122
				88.18    17597    3.390E-03    E3 from Cd-109
				112.42    1530    Ge escape from 122
				122.25    1411979    3.597E-03    M1+E2 from Co-57
				136.70    150082    3.058E-03    E2 from Co-57

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
284_003	13	200	5	284.0465
				<u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
				4.46    3657    Ge escape from 14.1
				6.42    16471    7.337E-05    Fe K-alpha-1&2
				6.97    8065    Co Kx-rays
				11.14    4459    Ge escape from 22.1
				12.44    24636    Ge escape from 22.1
				14.42    91426    2.087E-03    M I from Co-57
				22.12    426223    3.544E-03    Ag K-alpha-1&2
				24.95    84733    4.289E-03    Ag K-beta-1&2
				27.54    3275    edge from 29.7
				29.72    88853    6.549E-03    Xe K-alpha 1&2
				33.63    15057    6.333E-03    Xe K-beta 1
				34.45    3267    Xe K-beta 2
				39.62    10587    6.056E-03    M I + E2 from I-129
				84.93    36656    edge from 122
				88.15    92955    1.791E-02    E3 from Cd-109
				93.82    1462    edge from 122
				112.28    1295    Ge escape from 122
				122.25    1411915    3.597E-03    M1+E2 from Co-57
				136.68    149950    3.055E-03    E2 from Co-57

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
284_008	13	200	5	284.1863
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.42	1538		Ge escape from 14.1	
6.41	15128	6.739E-05	Fe K-alpha-1&2	
6.96	7867	2.310E-04	Co K x-rays	
11.15	4786		Ge escape from 22.1	
12.37	24945		Ge escape from 22.1	
14.41	91482	2.089E-03	M1 from Co-57	
22.12	426237	3.544E-03	Ag K-alpha-1&2	
23.98	2241			
24.95	84824	4.294E-03	Ag K-beta-1&2	
26.93	688		edge from 29.7	
27.32	710		edge from 29.7	
29.73	80323	5.921E-03	Xe K-alpha 1&2	
33.63	15274	6.424E-03	Xe K-beta 1	
34.42	3552	6.297E-03	Xe K-beta 2	
39.61	10619	6.074E-03	M1 + E2 from I-129	
84.85	23377		edge from 122	
88.26	18398	3.544E-03	E3 from Cd-109	
112.42	1389		Ge escape from 122	
120.89	704		Ge escape from 122	
122.24	1411911	3.597E-03	M1+E2 from Co-57	
136.66	149157	3.039E-03	E2 from Co-57	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
284_014	13	200	5	284.3262
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.47	1771		Ge escape from 14.1	
6.41	22029	9.813E-05	Fe K-alpha-1&2	
not identified		0.000E+00	Co K x-rays	
11.14	4330		Ge escape from 22.1	
12.43	24842		Ge escape from 22.1	
14.40	92862	2.120E-03	M1 from Co-57	
22.11	409783	3.408E-03	Ag K-alpha-1&2	
24.95	83449	4.224E-03	Ag K-beta-1&2	
28.15	3688		edge from 29.7	
29.72	88664	6.536E-03	Xe K-alpha 1&2	
33.63	15726	6.614E-03	Xe K-beta 1	
34.43	3761	6.667E-03	Xe K-beta 2	
39.60	11059	6.326E-03	M1 + E2 from I-129	
85.64	8032		edge from 122	
88.13	17894	3.447E-03	E3 from Cd-109	
122.23	1408583	3.588E-03	M1+E2 from Co-57	
136.67	148809	3.032E-03	E2 from Co-57	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
284_016	13	200	5	284.4661
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
4.48	1573		Ge escape from 14.1	
6.39	21966	9.784E-05	Fe K-alpha-1&2	
not identified		0.000E+00	Co K x-rays	
11.15	4380		Ge escape from 22.1	
12.45	24197		Ge escape from 22.1	
14.40	91327	2.085E-03	M1 from Co-57	
22.10	423432	3.521E-03	Ag K-alpha-1&2	
24.94	84019	4.253E-03	Ag K-beta-1&2	
29.71	91840	6.770E-03	Xe K-alpha 1&2	
33.61	15451	6.499E-03	Xe K-beta 1	
34.42	3447	6.111E-03	Xe K-beta 2	
39.59	10678	6.108E-03	M1 + E2 from I-129	
88.11	100305	1.932E-02	E3 from Cd-109	
89.08	45711		edge from 122	
93.75	4115		edge from 122	
112.39	1184		edge from 122	
122.21	1406579	3.583E-03	M1+E2 from Co-57	
136.66	149170	3.039E-03	E2 from Co-57	

## Mixed Source on Counter 18

<u>Standard</u>	<u>Reference date</u>	<u>Activity @ Ref</u>	<u>Half-life (d)</u>	<u>Emissions</u>	<u>Abn</u>
Fe-55	229.7083	0.467	997.13	5.888 5.899 6.49	0.082 0.162 0.0286
Ni-59	215.7083	0.260	2.74E+07	6.915 6.93 7.65	0.099 0.196 0.0356
Co-57	226.7083	1.034	271.77	6.391 6.404 7.058 14.41 122.06 136.47	0.164 0.325 0.058 0.0954 0.855 0.1069
Cd-109	336.5000	0.325	462.59	21.99 22.163 24.934 25.6 88.03	0.289 0.545 0.137 0.0272 0.036
1-129	250.7083	0.053	5.73E+09	29.461 29.782 33.606 34.606 39.571	0.204 0.378 0.102 0.0242 0.075

## Count Summaries:

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
271-042	18	300	5	271.7607
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.43	4277		Ge escape from 14.0	
4.54	29558		Ge escape from 14.1	
6.41	32272		Fe K-alpha-1&2	
7.01	14241	2.788E-04	Co K x-rays	
8.04	18800		Cu K-alphas	
8.88	2312		Cu K-betas	
11.12	16280		Ge escape from 22.1	
12.23	81740		Ge escape from 22.1	
14.41	272807	4.153E-03	M I from Co-57	
22.11	1256605	6.966E-03	Ag K-alpha-1&2	
24.93	294007	9.922E-03	Ag K-beta-1&2	
27.28	7753		edge from 29.7	
29.72	290648	1.428E-02	Xe K-alpha 1&2	
33.61	52627	1.476E-02	Xe K-beta 1	
34.43	12630	1.493E-02	Xe K-beta 2	
39.61	37826	1.442E-02	M1 + E2 from 1-129	
84.14	42285		edge from 122	
88.04	73958	9.498E-03	E3 from Cd-109	
112.14	5122		Ge escape from 122	
122.04	6957186	1.182E-02	M1+E2 from Co-57	
136.45	794476	1.079E-02	E2 from Co-57	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
272_018	18	300	5	272.1097
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.41	4239		Ge escape from 14.0	
4.52	30131		Ge escape from 14.1	
6.39	30692		Fe K-alpha-1&2	
6.97	12355	2.419E-04	Co K x-rays	
8.04	17059		Cu K-alphas	
8.90	2388		Cu K-betas	
11.08	16048		Ge escape from 22.1	
12.22	80576		Ge escape from 22.1	
14.40	263259	4.007E-03	M I from Co-57	
22.10	1253120	6.947E-03	Ag K-alpha-1&2	
24.92	294876	9.951E-03	Ag K-beta-1&2	
26.76	4002		edge from 29.7	
27.33	7235		edge from 29.7	
29.71	284260	1.397E-02	Xe K-alpha 1&2	
33.58	51212	1.436E-02	Xe K-beta 1	
34.43	12477	1.475E-02	Xe K-beta 2	
39.54	38403	1.464E-02	M I + E2 from 1-129	
83.84	31422		edge from 122	
85.47	20154		edge from 122	
88.00	75874	9.744E-03	E3 from Cd-109	
112.31	5314		Ge escape from 122	
122.05	6948091	1.180E-02	M1+E2 from Co-57	
136.46	792959	1.077E-02	E2 from Co-57	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
272-034	18	300	5	272.4586
<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>	
3.46	4747		Ge escape from 14.0	
4.53	31541		Ge escape from 14.1	
6.39	29631		Fe K-alpha-1&2	
6.99	11913	2.332E-04	Co K x-rays	
8.04	16335		Cu K-alphas	
8.85	1926		Cu K-betas	
11.12	16910		Ge escape from 22.1	
12.22	81874		Ge escape from 22.1	
14.40	270876	4.123E-03	M I from Co-57	
20.01	14918		edge from 22.1	
22.10	1306946	7.245E-03	Ag K-alpha-1&2	
24.93	291377	9.833E-03	Ag K-beta-1&2	
27.15	6284		edge from 29.7	
27.91	5526		edge from 29.7	
29.70	281331	1.382E-02	Xe K-alpha 1&2	
33.59	52106	1.461E-02	Xe K-beta 1	
34.40	11233	1.328E-02	Xe K-beta 2	
39.58	38099	1.453E-02	M I + E2 from 1-129	
83.79	35270		edge from 122	
84.99	24925		edge from 122	
88.01	75818	9.737E-03	E3 from Cd-109	
112.17	6714		Ge escape from 122	
122.04	6950530	1.180E-02	M1+E2 from Co-57	
136.46	790335	1.074E-02	E2 from Co-57	

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
273_004	18	300	5	272.8076
				<u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
	3.41	4168		Ge escape from 14.0
	4.52	29955		Ge escape from 14.1
	6.40	30508		Fe K-alpha-1&2
	6.98	12308	2.409E-04	Co K x-rays
	8.05	16560		Cu K-alphas
	8.87	2406		Cu K-betas
	11.13	16360		Ge escape from 22.1
	12.23	79746		Ge escape from 22.1
	14.41	270031	4.110E-03	M1 from Go-57
	22.10	1319779	7.316E-03	Ag K-alpha-1&2
	24.93	273580	9.233E-03	Ag K-beta-1&2
	27.04	5304		edge from 29.7
	27.98	6476		edge from 29.7
	28.58	8121		edge from 29.7
	29.71	274100	1.347E-02	Xe K-alpha 1&2
	33.60	51489	1.444E-02	Xe K-beta 1
	34.41	12421	1.468E-02	Xe K-beta 2
	39.57	37473	1.429E-02	M1 + E2 from 1-129
	83.65	25068		edge from 122
	84.22	25895		edge from 122
	88.02	75037	9.637E-03	E3 from Cd-109
	112.10	5870		Ge escape from 122
	122.04	6939271	1.179E-02	M1+E2 from Co-57
	136.45	788725	1.071E-02	E2 from Co-57

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Counttime</u>
273_018	18	300	5	273.1563
				<u>Energy</u> <u>Pk Area</u> <u>Efficiency</u> <u>Type</u>
	3.42	4556		Ge escape from 14.0
	4.54	31692		Ge escape from 14.1
	6.40	30491		Fe K-alpha-1&2
	6.99	12875	2.520E-04	Co K x-rays
	8.03	16502		Cu K-alphas
	8.91	2362		Cu K-betas
	11.12	17869		Ge escape from 22.1
	12.23	80376		Ge escape from 22.1
	14.41	262435	3.995E-03	M1 from Co-57
	19.94	15092		edge from 22.1
	22.10	1304382	7.231E-03	Ag K-alpha-1&2
	24.92	291337	9.832E-03	Ag K-beta-1&2
	27.00	8295		edge from 29.7
	28.47	8807		edge from 29.7
	29.71	281746	1.385E-02	Xe K-alpha 1&2
	33.59	51382	1.441E-02	Xe K-beta 1
	34.40	11297	1.335E-02	Xe K-beta 2
	39.55	38803	1.480E-02	M1 + E2 from 1-129
	84.42	21479		edge from 122
	86.03	10904		edge from 122
	87.99	74764	9.602E-03	E3 from Cd-109
	112.04	4488		Ge escape from 122
	122.01	6930803	1.177E-02	M1+E2 from Co-57
	136.42	787689	1.070E-02	E2 from Co-57
	143.75	512		sum of 22 & 122

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
273-035	18	300	5	273.1563
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	3.43	4055		Ge escape from 14.0
	4.54	29200		Ge escape from 14.1
	6.41	29912		Fe K-alpha-1&2
	7.00	13221	2.588E-04	Co K x-rays
	8.06	17028		Cu K-alphas
	8.93	1577		Cu K-betas
	11.13	16594		Ge escape from 22.1
	12.23	81637		Ge escape from 22.1
	14.41	264648	4.028E-03	M1 from Co-57
	22.11	1250775	6.934E-03	Ag K-alpha-1&2
	24.93	290824	9.814E-03	Ag K-beta-1&2
	27.30	3820		edge from 29.7
	29.71	264036	1.297E-02	Xe K-alpha 1&2
	33.60	51643	1.448E-02	Xe K-beta 1
	34.42	11167	1.320E-02	Xe K-beta 2
	39.58	37744	1.439E-02	M1 + E2 from 1-129
	84.57	44220		edge from 122
	87.99	73466	9.435E-03	E3 from Cd-109
	112.10	6024		Ge escape from 122
	122.00	6923165	1.176E-02	M1+E2 from Co-57
	136.41	788348	1.071E-02	E2 from Co-57

<u>SN</u>	<u>Counter</u>	<u>CL (min)</u>	<u>Shelf</u>	<u>Count time</u>
274-057	18	300	5	274.5829
	<u>Energy</u>	<u>Pk Area</u>	<u>Efficiency</u>	<u>Type</u>
	3.4	3990		Ge escape from 14.0
	4.5	29948		Ge escape from 14.1
	6.4	29685		Fe K-alpha-1&2
	7.0	12931	2.531E-04	Co K x-rays
	8.0	16011		Cu K-alphas
	8.9	1486		Cu K-betas
	11.1	16282		Ge escape from 22.1
	12.2	81505		Ge escape from 22.1
	14.4	269223	4.098E-03	M1 from Co-57
	22.1	1317118	7.302E-03	Ag K-alpha-1&2
	24.9	267929	9.042E-03	Ag K-beta-1&2
	27.4	2580		edge from 29.7
	29.7	263288	1.294E-02	Xe K-alpha 1&2
	33.6	52031	1.459E-02	Xe K-beta 1
	34.4	12566	1.485E-02	Xe K-beta 2
	39.6	38111	1.453E-02	M1 + E2 from 1-129
	84.1	36316		edge from 122
	85.7	21585		edge from 122
	88.0	73730	9.469E-03	E3 from Cd-109
	112.0	3210		Ge escape from 122
	122.0	6910941	1.174E-02	M1+E2 from Co-57
	136.5	785727	1.067E-02	E2 from Co-57